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NATIONAL ACADEMY OF SCIENCES
BIOGRAPHICAL MEMOIRS
PART OF VOLUME VII

# BIOGRAPHICAL MEMOIR

OF

# ALEXANDER AGASSIZ

1835-1910

BY

GEORGE LINCOLN GOODALE

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1912

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# ALEXANDER AGASSIZ.

BY GEORGE LINCOLN GOODALE.

An exhaustive memoir of Alexander Agassiz should consider his achievements in three distinct fields, namely, mining-engineering and administration, oceanographic research, and zoölogical investigation. His power of mental concentration and his economy of time enabled him to accomplish results which might fairly be regarded as full measure of activity for three men. To specialists in engineering, oceanography, and zoölogy must be entrusted the appreciation of the results attained; to one who has no claim to authority in any one of these fields of thought has been given the task of tracing in outline the principal dates in the career of Alexander Agassiz.

A large part of the energy of Agassiz was devoted for almost half a century to the enlargement of the Natural History Museum created by his father, and to the realization of his father's dream. The zoölogical section of this museum, known as the Museum of Comparative Zoölogy, was early placed in the hands of a small body of trustees, termed its faculty, and of this faculty Mr. Agassiz, after his father's decease, was always an active member. The present writer has had the privilege of membership in that faculty for nearly thirty years, and this affiliation brought him into intimate relations with its moving spirit. This unbroken intimacy constitutes the only apology which the writer can offer for having dared to accept the command from our president to prepare the present sketch.

Alexander Agassiz was born at Neuchâtel, Switzerland, December 17, 1835. His father, Louis Agassiz, was an instructor in the newly founded academy there, and had already secured a wide reputation as a naturalist. His mother, a sister of Prof. Alexander Braun, a distinguished botanist, possessed remarkable talent as an artist, and aided her husband greatly by the exact illustrations with which she enriched his scientific publications. The zeal for research and the artistic temperament which characterized father and mother descended to the son.

Alexander's early studies were conducted at Neuchâtel, a city where French is the spoken language. But as his mother was a German, he had at his services, from his earliest youth, the two languages, German as well as French. When he was eleven years old, he went to Freiburg in Baden, where he came into touch with his uncle, Alexander Braun, for whom he was named, and with Prof. K. Theo. v. Siebold. In a private manuscript dated 1907, he says that it was from them that he "imbibed his first notions of natural history."

At the age of thirteen, after the death of his mother, he came to the United States to join his father, Louis Agassiz, who had accepted a professorship of zoölogy and geology in the Lawrence Scientific School, which had been recently established. At once he began his studies in the high school in Cambridge, and after two years of preparation entered Harvard College, graduating in arts in 1885, at the age of nineteen. Since his earliest years had been passed in French and German-speaking countries, he always found it a little difficult to pronounce certain English words, but his mastery in the construction of English sentences and his felicity in the choice of words were remarkable. When he wrote slowly his writings were models of clearness and precision.

After receiving his degree in arts, he carried on studies in the Lawrence Scientific School, and took a degree of bachelor of science, in engineering, in 1857. It should be mentioned in connection with this fact that he later pursued a course of studies in natural history in the same school, while he was assistant in the museum, and was given a second degree of bachelor of science, in 1862. The years 1858 and 1859 were in part devoted to teaching and to chemical work.

In 1859 he went to California as an aid in the United States Coast Survey, and passed a year in active service in the northwest. On his return to Cambridge, in 1860, he accepted a position as assistant in the Museum of Comparative Zoölogy, then just founded. In the same year he married Miss Anna Russell, a sister-in-law of Col. Theodore Lyman, his classmate in college and an associate in the museum.

Three years later he became interested in coal mining in Pennsylvania, but he still continued active work in zoölogy. In 1865 he undertook the exploitation of an unprofitable copper mine in Michigan, in which he detected great possibilities. By uniting this mine with an adjoining one and by the application of improved methods of ore treatment, he placed the consolidated properties upon a productive basis. From this time on, he had no further dread of the narrowness of means which had hitherto hampered him and his father; moreover, he could henceforth liberally aid his father in the furtherance of plans for the symmetrical expansion of the museum, and form for himself generous projects for exploration as well as for museum study. In spite of the too serious drafts made by the mining enterprise upon his time and strength, he did not at any time relinquish his interest in its management. He served successively as superintendent, treasurer, and president.

In 1869 his health gave way under the protracted strain of the management of the mine in Michigan, and he was forced to suspend all work in connection with that undertaking. With his wife and children he sailed for Europe in the autumn of that year, and his rest soon found him convalescent. With returning strength he journeyed to various points where he could examine collections of his favorite objects of study, and thus he spent his vacation in the most pleasurable scientific activity.

The titles of the scientific papers noted at the end of this sketch exhibit the wide range of his investigation and the steadfastness of his purpose. At this period he was devoting himself with singleness of aim to embryology and certain phases of systematic zoölogy. In this work and in his devotion to the museum, he must have given great satisfaction to his father, who always regarded him as his earliest student in the museum. His methods of study were largely those of his father, and his avoidance of the polemics of Darwinism at this time was an added gratification. This period is regarded by those best qualified to judge as the happiest and most productive of the years which he gave to zoölogy proper.

Toward the close of 1873 his father died. Before the end of the year his wife also passed away. The effect of this loss upon a strong personality, endowed with a highly sensitive temperament, has been told in touching words by his intimate friend Sir John Murray. It is enough for us to say that no change of scene or of work ever seemed to lessen the sense of that bereavement.

Even when a youth he had been much attracted to the study of the sea itself, and the distribution of its animals. In this study and in far journeying he now sought distraction from his loss. He began to give to exploration and oceanography a part of the time he had formerly devoted to embryology and systematic zoölogy.

His first expedition was to South America. He explored certain portions of the coast regions of Chili and Peru, and gave special attention to Lake Titicaca. He charted the lake and determined its chief biological features, making collections illustrating its flora and fauna. He brought home also much archæological material. It is interesting to note that he gave a certain amount of attention to important geological aspects, especially to the question of land elevation.

In all of the numerous expeditions conducted after this date he continued his survey on a broad basis, neglecting nothing which might throw light on the relations of the lands explored.

For each of his expeditions, ample preparations were made long beforehand with regard to arrival at ports of call, selection of favorable seasons, adequate provision of coal, and requisite appliances for deep-sea work. The whole course of each expedition was marked out accurately before he left Cambridge, and every precaution was taken to guard against misadventure. Hence he never met with any serious detentions. He was able to prosecute his work without interruption. In the exact records of these expeditions, the reader will find that the narrative itself is devoid of anything of a personal nature, and nowhere will be detected the fact that in a large part of each sea voyage, the leader of the survey was often completely prostrated by seasickness. His strength of will overcame all obstacles.

In his youth Agassiz made with his father, and later by himself, excursions along the Atlantic coast, and he early became familiar with the technique of dredging. In 1877, as director of the scientific staff of the United States Coast Survey steamer "Blake" he became specially interested in oceanographic problems. In this steamer he made three cruises in the Gulf of Mexico, the Caribbean Sea, and along the lower east coast of the United States. In subsequent expeditions, he gave attention to the pelagic fauna of the Gulf Stream.

His voyages in the Pacific were made partly in the Fish Commissioner's steamer "Albatross," and in steamers chartered by himself. He left practically no important locality unvisited. The accounts which he gives of the coral and other islands examined by him, together with the results of his thalassographic researches, are embodied in illustrated quarto volumes and in the numbered publications of the museum which are noted in the bibliography accompanying this sketch. Many of the photographs reproduced in the numerous works were taken by his son Maximilian, who was his constant companion.

Mr. Agassiz passed the greater part of every winter in some climate milder than that of Cambridge, and he so planned his journeys as to make every month tell. In this manner he was able to accomplish an enormous amount of geographical examination without disappointment or disaster. On his return to the United States, after these long journeys, he would devote a certain amount of time to the mines in Michigan and then resume his zoölogical and other studies at the museum in Cambridge, but chiefly at the laboratory in Newport. His friends in Cambridge, Boston, and Newport were not infrequently permitted to hear from Mr. Agassiz a preliminary and familiar account of his latest wanderings and achievements. It is much to be regretted that none of these instructive untechnical reports of great accomplishments have been preserved. They possessed the charm which is associated with the remembrance of his father's lectures.

As has just been said, Mr. Agassiz conducted his laboratory studies based on the material gathered from his numerous expeditions, mainly at his home at Castle Hill, Newport. Near his residence he established in 1877 a sea-side laboratory well equipped with all requisite appliances. This laboratory was indirectly an outcome of an experiment on the island of Penikese. Louis Agassiz, a year before his death, had been offered the use of this island, together with a certain sum of money, for the founding of a summer-school for instruction and research in marine zoölogy. Alexander did not favor the acceptance of the offer, but he gave his loyal assistance, after the experiment had begun. Prof. Asa Gray rightly called the enterprise "the fatal gift of Penikese." Louis Agassiz was not at the time sufficiently strong to bear the additional burden of a doubtful experiment, and his death soon followed. But his son fully appreciated the desirability of having some place for research on the south shore, and he therefore established a laboratory near his home in Newport. This laboratory was opened to instructors and students from Harvard and other colleges, under most charming and hospitable conditions, and remained active until 1897, when the neighboring waters were not wholly favorable for its further activity. Moreover, the establishment of a marine biological station at Woods Hole under the auspices of the Fish Commission rendered the maintaining of a public laboratory unnecessary.

Mr. Agassiz had also a home in Cambridge. This was presided over by his father's second wife, Elizabeth Carey Agassiz, a lady of gracious presence and wide accomplishments. Her active interest in all things pertaining to the life of her husband and step-son was shown by her earnest work in conducting a school for young women, in order to add to the slender means of the family, in the early days. Her interest in the museum never slackened. She herself was an enthusiastic student of natural history, particularly on the instructional side, and, at a period when good handbooks were uncommon, assisted Alexander in preparing a useful treatise, known as Sea-Side Studies, a work which passed through two editions. Every move in every expedition, from the moment when Mr. Agassiz left Cambridge until his return, was watched by her with intelligent interest.

The Museum of Comparative Zoölogy, to which frequent reference has been made in this sketch, was founded by Louis Agassiz upon a plan which is not at all adequately described by its name. What he had in mind, as indicated by hints in his reports and other communications, was a museum for research and illustration in all departments of what was then called natural history. It was intended to comprise everything from minerals, through the kingdom of plants, to the highest animals. It was to include also man regarded from an archæological and ethnological point of view. The first section of this comprehensive museum was erected in 1859.

The staff at the outset consisted of a curator, Louis Agassiz, and numerous assistants, each in charge of a department of zoölogical investigation.

In the capacity of assistant, Alexander Agassiz served until 1875, when he was made curator. A second section of the museum, devoted to zoölogy, was added to the structure in 1871-1872. In 1876, the section known as the Peabody Museum of American Archæology and Ethnology, was erected at the southeast corner of the great quadrangle, where its apparent isolation gave little hint of the comprehensive plan which makes it an integral part of the whole edifice.

By the close of 1882, the building had been extended to the extreme northwest corner. Practically all of these additions were made from gifts by Mr. Agassiz. In 1888 and 1889, further extensions were made to accommodate mineralogy and a part of the botany, and to provide more room for zoölogy. At this period another section was also added to the Peabody Museum. It was largely through the active influence and the direct gifts of Mr. Agassiz that these additional sections were constructed. The façade fronting on Oxford Street still lacked an important element, namely, the southwest corner. In 1901-1902, this was filled by the commodious sections devoted to geology, the gifts of Mr. Agassiz and his two sisters, Mrs. Shaw and Mrs. Higginson. In other words, the children had effectively carried out their father's original plan, and the great museum is now approaching completion. During this whole period Mr. Agassiz served the museum as an officer: 23 years as curator, 10 as director of the Museum of Comparative Zoölogy, and from 1902, until his death, as director of the University Museum, comprising all the sections. His gifts to the museum and to other departments of Harvard University considerably exceeded a million dollars.

It might naturally be thought that so busy a man, and one who had devoted to much of his time, energy, and means to the museum of the university, might fairly be excused from any further demands by the university itself. But his services were sought and freely given as overseer and as fellow of the corporation.

Mr. Agassiz took a deep interest in the scientific societies which have their headquarters within reach of the museum, and for one of them, the American Academy of Arts and Sciences, he has made by his will a liberal allowance for a permanent home.

Of his fondness for the National Academy of Sciences there is no need that one should speak here. All can appreciate what he has done for it and for its future development. There is hardly a scientific society which does not carry his name on its rolls. There is not one which does not value his contributions to science as among the most important in their libraries.

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OF

# JOSEPH BARRELL
## 1869-1919

BY

CHARLES SCHUCHERT

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1925

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# JOSEPH BARRELL, ENGINEER-GEOLOGIST

## 1869-1919

BY CHARLES SCHUCHERT

JOSEPH BARRELL'S scientific life coincided with the "Golden Era" of Geology in America, and in him American Geology has lost a leader who promised to stand as high as the highest. "Those whom the gods love, die young." His period of educational preparation, balancing of personal characteristics, and storing up of fundamental experiences was back of him. Had he lived longer he would have become the chief exponent in the subjects of geologic sedimentation, metamorphism, structural geology, the geologic bearings of isostasy, and the genesis of the earth. T. C. Chamberlin writes: "We had come to look upon him as one of the most promising leaders in the deeper problems of earth science"; Bailey Willis, that "there is unanimous recognition of the fact that Barrell was one of the strongest of the younger leaders and a man of great promise"; John M. Clarke, that Barrell's death "is a truly overwhelming disaster for American Geology."

Upon his colleagues at Yale, Barrell's death, following so soon after that of Irving, fell as a heavy blow. Coming to us as a matured and highly educated young man, we saw Barrell grow into a leading geologist who exceeded our hopes and more than justified our choice of him to fill the chair of Structural Geology created for him at Yale. He was a power among us, and it was around him that our graduate courses in Geology were built. Personally, we are bereft of a friend and councillor whose place can not be filled—one whose simplicity of nature and strength of character were unique. His great fund of knowledge was always gladly placed at our disposal, and his constructive criticism and fertility of suggestion have been the stimulus to more of our work than we shall ever realize. We rejoice that the privilege was ours of working with him, and in our hearts there will always remain the grateful memory of his inspiring personality.

Barrell's death occurred in New Haven, Connecticut, on May 4, 1919, after a week's illness with pneumonia and spinal meningitis. He left a wife, Lena Hopper Bailey, and four sons, Joseph, Herbert Bailey, William Colburn,* and Richard Lull. Standing 5 feet 10.5 inches in height, of the blue-eyed Nordic type, with a full head of wavy light brown hair, he was pale and spare of build, and yet of great muscular strength—the "strong man" of his class at Lehigh. Once seen, he was easily remembered, and he was quickly picked out in a crowd. This was due in part to his tall slender build, his long and awkward stride, and his confident bearing, but more especially to the strength of character reflected in his large features, particularly the wide mouth and long, narrow nose, concave in profile. He prided himself on the longevity of his ancestors, and from a careful study of insurance tables held the unshakable belief that some thirty years of active life were ahead of him.

Modest and optimistic, with a strong independence of mind, he prized true worth highly, and was easily aroused to criticism of posers and social climbers, and of shams and errors. Simple in attire, and fond of simple living, his intellectual ideals were of the highest. He cared little for popularity, or for adverse criticism, and not much more for praise. His colleague, Professor Gregory, says that what he valued most was "uninterrupted time for research and intellectual fellowship established through writings. His intellectual power was so obvious and so continuously displayed that twenty years of intimacy has left on me an impression of a mind rather than of a man. His mind was of surpassing fertility, imagination, and machine-logic." In appearance and mentality, Barrell reminded his older colleagues at Yale of James D. Dana; whatever subject these two great geologists touched was made clearer and the way indicated for new lines of research.

A man of science, and especially one deeply interested in generalizations, should be endowed with imagination under restraint. Barrell had a great deal of this quality, and loved to speculate under the limitations of the "multiple hypothesis." No man ever had better developed the power of detachment from his own views. He could examine his conclusions from all angles. As Davis says, "He interested himself in thinking about how he thought, and tried to evaluate the results of his thinking. He was as careful and critical in this respect as he was fertile and ingenious in mental inventions."

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* Since deceased.

An omnivorous reader and a very hard worker, Barrell never tired of unraveling the intricacies of earth structure, and having a marked faculty for picturing his thoughts, he not infrequently expressed an idea in graphic form before he put it in writing. His method of presenting a subject was to prepare his reader for what was to come, and then to set forth in detail the processes and principles that underlie the results sought for. This is why most of his papers are lengthy and in places tedious. His earlier articles were not well written, and he constantly sought to improve this weakness.

In the scheme of instruction at Yale, Barrell had charge of two classes: a half-year undergraduate course in Historical Geology, and a full-year course, primarily for graduates, in Dynamical and Structural Geology. At times he also took part in teaching small groups in Field Geology, and nearly every year he gave a special course to graduate students in which the literature and the solution of problems along structural and dynamic lines constituted the subject-matter. Before the class, Gregory says, "he was the geologist rather than the teacher of untrained minds. . . . The recognition of the average undergraduate viewpoint played little part in his teaching." Accordingly, in his earlier career at Yale the boys found him too statistical, and on the campus he was known as "Old Bathylith" and "Interstitial Relations"; later, however, these friendly nicknames vanished.

In graduate teaching, Gregory continues, "where analytical thought, mental invention, breadth and depth of knowledge make the successful instructor, Barrell had few equals." The more mature his students, the more enthusiastic they were in his praise, and he gave them much that was not to be found in books. Difficult his course was, and exacting his examinations, but the student who completed them was thoroughly grounded in the principles of Dynamical and Structural Geology.

## FAMILY HISTORY[1]

The name Barrell, spelled in many ways, had its origin among the ancient land-holding knights of Normandy, and appears in England for the first time with the battle of Hastings and William the Conqueror in 1066. The first of the family to migrate to America was George Barrell, a cooper by trade, who arrived at Boston from St. Michaels, Suffolk, in 1637, and died there in 1643. He became a freeman of the Boston parish on May 10, 1643, and owned a house and a half acre of ground (for which he paid 31 pounds) on what is now the southeast side of Hanover Street between Elm and Washington. He had but two sons, and one of them, John, also a cooper by trade, married Mary, daughter of William Colburn, one of the twelve original founders of the colony. It is from this union that all of the American Barrells of colonial origin have sprung.

Until recently, the Barrells have been in the main sea-going people, ship-owners and merchants. The second John Barrell was a mariner, and his son John a well educated man and a successful shipping merchant. Professor Barrell in his genealogy of the family says of John III: "The hazards of travel and of residence in tropical lands, however, told severely upon their number, so that notwithstanding several large families of sons, his descendants bearing the name have remained few in number and widely scattered."

The most widely known and wealthiest was Joseph Barrell of Boston (1739/40-1804), after whom the subject of our sketch, his great grandson, was named. He married three times and had twenty children. This Joseph Barrell was an original thinker and a good speaker and writer. He is said to have "early espoused and firmly maintained the cause of his country," and for a time represented the town of Boston in the State Legislature. He lived well, and it was in his splendid home that General Washington was entertained during his visit to Boston. He was also one of the group of men who fitted out the ship "Columbia" and sent her into the Pacific, where in 1792 her crew discovered the Columbia River. Later they purchased of the Indians the territory about this stream, and in this way began the colonization of what have since grown to be the Northern Pacific States of the American Union.

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[1] Taken from a genealogy of the Barrell family prepared by Professor Barrell, but not published.

The father of Professor Barrell, Henry Ferdinand, was born in New York City, October 3, 1833. His son says he "grew up with a strongly developed taste for books, for nature, and for life in the country." Henry Ferdinand's father bought him a farm near Warwick, Orange County, New York, and it was here that he met his wife, Elizabeth Wisner, whom he married on March 15, 1858. The Wisners, originally from Switzerland, had been real estate holders for 150 years and officers in the colonial and later wars. In 1864, Henry Ferdinand Barrell sold this farm and bought another at New Providence, New Jersey, and here from 1875 to 1895 he served as chairman of the trustees of the public library and of the public school in which the subject of this sketch received his primary education. He had nine children, of whom Joseph was the fifth child and the fourth son.

## ACADEMIC CAREER

Joseph Barrell, the subject of this memoir, was born at New Providence on December 15, 1869. As a child, he was more interested in books on natural history, astronomy, and history, than on general literature. His mother, after whom he takes, related to the writer that frequently he would get a volume of the Encyclopedia Brittanica and sit for hours reading it. At the age of ten years, he was given a planisphere and often at night would take it and a book on astronomy, along with a lantern, and then lie on his back gazing at the stars, and so learn their names with the aid of the planisphere. Joseph attended the public school until he was sixteen years old, and two of his teachers prepared him privately for college. Before going to college, however, it was necessary for him to earn some money, and so he taught school during 1886-1887. For this he received two hundred dollars, and with further assistance from his parents he attended the Stevens Preparatory School at Hoboken the following year. Here he won a scholarship for Stevens Institute, but preferred a college course at

Lehigh University, which he began in September, 1888, and completed four years later with high honors. In 1893 he received from the same university the E. M. degree, in 1897 its M. S., and in 1916 its doctorate of science.

In a sketch of himself written for the twenty-fifth anniversary of his graduation at Lehigh, Barrell says that in 1893, when he received his engineering degree, "I regarded myself as lucky in securing an instructorship at Lehigh in mining and metallurgy." This position he held for four years, teaching mechanical drawing, mining and metallurgical design, making shop visits to various metallurgical plants, and practising surveying with students in the anthracite mines. "Teaching," he goes on to say, "is always better training for the teacher than for the taught. . . . The summers were put in in gaining experience, parts of the winters were employed in studying Geology and practical Astronomy, for which Lehigh gave me the degree of M. S. in 1897." His thesis in fulfillment of the requirements for this degree is 419 pages long, and is entitled "The Geological History of the Archean Highlands of New Jersey, including their Extension in New York and Pennsylvania." In it appear some of the problems on which he later worked so much.

In 1898, Professor E. H. Williams, Jr., contemplating a division of his work at Lehigh, persuaded the university to hold vacant for two years the position of assistant professor of Geology, provided Barrell would spend that time at Yale in advanced work. Barrell says that this opportunity "was a most generous one. I spent the following two collegiate years at Yale and the summers working in Montana for the U. S. Geological Survey in general and mining Geology." In 1900 Yale gave him the degree of Ph. D., and tradition has it that he was the ablest student of Professors Penfield, Pirsson, and Beecher. In this way, as Barrell says, "a mining and metallurgical education, combined with a panic year on leaving college, had led logically into a career as a geologist. The initial engineering education and the experience of the eight years following 1892 formed the broad and solid base on which the following work has been built."

For three years after 1900, Barrell taught Geology at Lehigh, with Zoology as a side issue. In 1902, he was married there to Lena Hopper Bailey. The three summer months of the year preceding were spent in Europe with Professors Herbert E. Gregory and Charles H. Warren, travelling "by foot, by bicycle, and by third-class trains, the object being to see the countries and study Geology rather than to do sightseeing in the cities."

"What better course," says Gregory, "could be devised for a man set aside as a physical geologist than that chosen for and by Barrell: elementary school and high school in a rural village, a year at a city preparatory school, four years of engineering studies, six years of mining practice combined with teaching of mathematics, astronomy, mining and metallurgy, and capped by two years of graduate study of field and laboratory problems? Few men at the age of thirty-one have built such a broad and solid base for a future scholarly career."

In 1903, Barrell was asked to come to Yale to develop the field of Structural Geology, and his decision to accept the invitation was the turning point in his career, since by it he turned his back on the more profitable field of mining engineering and set his face toward graduate teaching and research. He was at first assigned to the Sheffield Scientific School, but Professor Gregory's classes in Geology in Yale College had grown so rapidly that Barrell was transferred to that department of the University in the following year. Needing still more help, the College in 1905 appointed Isaiah Bowman to teach Physiography and Geology, and two years later Ellsworth Huntington came to give work in Geography. All of this teaching was done in the Peabody Museum, where E. S. Dana, Charles Schuchert, and R. S. Lull also had their offices. This group of men reacted intellectually on one another in their daily intercourse, and here the extent of Barrell's dynamic influence can not be measured, except as the printed product of the other men in the decade between 1905 and 1915 bears testimony to it.

Barrell was a member of the honorary scientific society of the Sigma Xi, and president of the Yale Chapter in 1914. He was also elected to the Phi Beta Kappa Chapter of the same University. He was a fellow of the Geological Society of America, the Paleontological Society, and the American Association for the Advancement of Science, and a member of the American Academy of Arts and Sciences. Only four days before his death, there came to him the news of the highest honor that can be given to an American scientist, election to the National Academy of Sciences.

As a lecturer, Barrell was often called on by other universities. In 1912 he gave a series of five lectures at the University of Illinois, dealing with "The Bearing of Geology on Man's Place in Nature" and "The Measurements of Geologic Time." In 1914 he gave a course of three Sigma Xi lectures at the Universities of Missouri and Kansas. At Columbia two years later he gave six lectures on isostasy, and at Yale he presented before the Sigma Xi and Phi Beta Kappa societies his interesting talk on "The Habitability of Worlds."

## WRITINGS

An analysis of Barrell's writings shows that he progressed from simpler relations to the most complex of geologic problems. It is also clear that his best results were obtained through generalizing from the publications of others. He loved to assemble the published data derived from field and laboratory, and along with his own observations, subject all to the test of multiple hypotheses, so as all the better to ascertain the correct explanation of the facts examined. As Willis has said, Barrell was first an engineer in Geology, since his training had led him to precise habits of thought, and it is this characteristic that especially distinguishes his work. He himself has said that "geologic research in the past generation has been passing out of the qualitative stage and has partaken notably of the quantitative character."

Barrell's first publications, in 1899 and 1900, deal in mining, but those since 1901 have nearly all had to do with Geology. His bibliography, if completed in detail, would take note of about 150 notices and reviews of books, most of which appeared in the *American Journal of Science*. Of these, nineteen contain original matter and are therefore included in the bibliography which accompanies this sketch; in general they deal with isostasy, the origin of the earth, and metamorphism, the subjects with which he was most familiar. When he set himself to write a review of a book, he produced a lucid analysis, with discussions of the conclusion attained by the author.

Of short papers and longer memoirs, his bibliography includes about sixty, totalling nearly 2000 pages.

## MINING ENGINEERING

Barrell's first experience as a mining engineer was in 1894, with the engineering corps of the Lehigh Valley Coal Company, at Wilkesbarre, Pennsylvania. In June, 1897, he joined the staff of the Butte and Boston Mining Company of Butte, Montana, and worked with them and the Boston and Montana Company for over a year. "The work was interesting," he says, "and involved difficult problems in the plumbing of crooked shafts, and the measurements of amounts of ore extracted from old workings." These experiences led to his publishing in *Mines and Minerals* during 1899 and 1900 a series of five papers which he wrote while at Yale studying for the doctor's degree. These papers have to do with the methods and errors of mine surveying,—instrumental errors, methods of keeping stope books, and choice of survey instruments. They abound in mathematics and in diagrams, and thus foreshadow two of Barrell's future tendencies in Geology.

## REGIONAL GEOLOGY AND METAMORPHISM

During the summer months of 1899, Barrell was field assistant to W. H. Weed of the United States Geological Survey, mapping the ore-bearing formations of the Elkhorn Mining District of Montana. This work, Barrell states, was done alone, much of it on horseback, in the mountainous region between Butte and Helena. It involved a study of the great successive intrusions of molten rock which in the early Tertiary had broken up the crust and brought in the wealth of gold, silver, and copper. The first result of these field studies was the publication of the "Geology and Ore Deposits of the Elkhorn Mining District," by W. H. Weed, with an "Appendix on the Microscopical Petrography of the District," by Barrell.

These observations Barrell made the basis of a dissertation for the doctorate when he returned to Yale in the autumn of 1899. Under the guidance of Professor Pirsson, he made an elaborate petrographic study of the rocks, along with the geology of the Elkhorn area, resulting in a dissertation which was entitled "The Geology of the Elkhorn Mining District."

This Elkhorn work contained a chapter on "The Physical Effects of Contact Metamorphism," which was published in abstract in the *American Journal of Science* in 1902. In this paper Barrell discussed the changes of mass and volume through metamorphism, and stated, among other things, that the shrinkage in rock of certain compositions may be "from 25 to 50 per cent in volume, attended with the evolution of great quantities of gases which at surface pressures and temperatures would amount to several hundred times the volume of the original sediments."

In the summer of 1900, Barrell was again employed by the United States Geological Survey in a two months' reconnaissance of the surface geology of the Deerlodge region of Montana, and of the underground geology of Butte. The next year he began, again under the direction of Weed, a three months' geological survey of the surface and underground geology of the Marysville mining district, Montana. These results, also worked out at Yale and published as "Geology of the Marysville Mining District, Montana: a Study of Igneous Intrusions and Contact Metamorphism," reveal a mastery of petrography and chemical mineralogy. The region was one of the noted gold-producing centers of Montana, and the mines were situated around the margins of the irregular Marysville bathylith of quartz diorite. The Marysville bathylith is "but 6 miles at its nearest point from the exposed surface of the far greater Boulder bathylith, a granitic mass which is petrographically a quartz monzonite in normal composition. The Boulder bathylith possesses a general rudely rectangular form, occupying about 60 miles in latitude by about 35 in longitude, and holds within its confines the mining city of Butte, from which for many years past has poured a flood of silver and a quarter of the world's copper. Other smaller mining centers also lie within this large granitic area, while such important ore deposits as those of Elkhorn and Unionville, south of Helena, have been found about its margin."

The Marysville report has now become one of the classics in Geology, and of it Pirsson in a review in the *American Journal of Science* says: "The special character of this work lies in the detailed investigation of the bathylithic body, of the method of intrusions, of its form, and of its relations to the surrounding rock masses both past and present." The intrusion Barrell could not explain by the accepted methods, and did so by a new theory, that of magmatic stoping. Daly, in his book "Igneous Rocks and their Origin," states that "It was in the Cordilleran region, at Marysville, Montana, that Barrell independently originated the stoping theory of magmatic emplacement."

Because of the large scale on which the Boulder and Marysville bathyliths are exposed, and because of the forceful presentation of the field relations and the clearness of Barrell's inferences therefrom, Suess, in his great work, "The Face of the Earth" was led to say that the Marysville report is "one of the most instructive works produced in modern times" connecting granitic invasions with volcanoes.

In 1904 appeared Van Hise's epochal "Treatise on Metamorphism." Great in volume and depth of thought, this book made a profound impression on Barrell, and his copy of it was read and re-read so often that it soon fell to pieces. All of Barrell's students also had to do much reading in this book, and in 1905 he wrote an extended review of it for the *American Journal of Science,* in which he states that Van Hise has made of metamorphism "an exact science," that its phenomena express the "chemical and physical laws operating within the crust of the earth," and that they are here presented "in the most systematized form." The book is a "landmark of a new era." To Barrell, however, Chapter 11 was the most interesting, since it treats of the relations of metamorphism to the distribution of the chemical elements, and in his notice he devotes more than one half of the space to it.

Metamorphism always remained one of Barrell's foremost lines of study, and as late as 1914 he wrote "Relations of Subjacent Igneous Invasions to Regional Metamorphism."

This paper was published in 1921 under the editorship of Professor Frank F. Grout. Some of its summations are as follows: Bathyliths come into place either accompanied by crustal compression, as in the Appalachians, or without folding, as in the Cordilleras. The features of metamorphic rocks are due in the main to bathylithic invasion and compression; to a less extent to movements of solutions, selective crystallization, lit-par-lit injection gneisses, and the alternation of injection and mashing. Magmatic solutions are not of meteoric origin, and the results in minerals depend upon equilibria,—largely on the presence of $H_2O$ and $CO_2$.

## EROSION, SEDIMENTATION, AND CLIMATOLOGY

After some years as an instructor of graduate students in Dynamic Geology, Barrell's ideas in regard to processes of erosion, sedimentation, the formation of deltas, and the discerning of ancient climates in the sediments took form, and it was on these subjects that he next wrote. He it was, more than any other, who led geologists away from the prevalent idea that nearly all strata are of marine origin, and toward what Coleman has called "dry land geology," namely, to the recognition that one fifth of the present lands are mantled by continental deposits. Nearly one fourth of his publications follow these lines. As Vaughan says, Barrell organized the principles of sedimentation "into a consistent body of usable criteria, and applied them to the interpretation of many formations." He also did much to build up the science of Paleoclimatology, and in Paleogeography he established principles for discerning the shore-lines of the seas, and the extent and elevation of the ancient lands that were furnishing the marine sediments. Had he lived longer, he would have done much more, for an unusually stimulating opportunity had come to him as chairman of the newly founded Committee on Sedimentation in the National Research Council.

In 1906, Barrell published a series of three papers on the "Relative Geological Importance of Continental, Littoral and Marine Sedimentation" in the *Journal of Geology*. Here, as in most of his papers on sedimentation, he is dealing with fresh-water deposits, those of deltas, and those of the littoral region of the seas. To have a correct knowledge of marine sediments one should of course know their origin and nature on the lands, and while this logical sequence for study had much to do in leading him to work mainly with continental formations, the fact of his environment probably had most to do with these predilections. Barrell was raised on Triassic strata that are composed of conglomerates of fresh-water origin, and as a teacher of students at Yale his excursions were largely to fresh-water and estuarine strata. James D. Dana had long been explaining the Triassic strata in eastern North America as of estuarine origin; to-day everyone sees that their genesis came through fresh water in areas between the mountains of Permian making, and under semiarid climates.

In these three papers, Barrell sets forth a quantitative view as to the relative geologic importance of continental, littoral, and marine types of sediments, and the criteria for separating them. It is a study of facts already assembled in the geologic literature, and an application of changing and cyclic geographies to stratigraphy. Among other things he develops the criteria for discerning subaerial delta deposits, and shows that such attain their greatest development after epochs of mountain making unaccompanied by notable uplift of the continental platforms. "The ratio of continental to marine sediments," he says, "should have fluctuated widely through geological time. Following an epoch of continental uplift with mountain-making, the deposits formed in interior basins should attain a maximum, especially the deposits made under desert conditions." Finally, when the lands are greatly reduced, the burden of the rivers is largely that of solution materials, resulting in the wide spread of shallow-water marine deposits.

He also emphasizes the cyclic relations between continental and marine sedimentation in geologic history. The wide and cyclic significance of mud-cracks in association with other features indicating flood-plain deposits is discussed at length and applied to the interpretation of Proterozoic deposits in Montana and the Grand Canyon of the Colorado.

The significance of desert deposits becomes very striking when one notes that one fifth of the present land surface is desert tracts. Barrell estimates that the subaerial deposits of piedmont waste, of continental basins, and of deltas cover about one tenth of the emerged continental surfaces. Adding these "to the estimate of the deposits of arid climates would give a fifth of the land surface as mantled by continental formations." The lands, in the course of the geological ages, are, however, warped and elevated into mountain ranges, so that the geological record "should show a far less proportion of thin and superficial land deposits." On the other hand, basin and delta deposits should be quantitatively as great as those laid down upon the floor of the epeiric seas.

Having developed the principles of sedimentation for continental and shallow-water marine deposits, Barrell applied them in 1907 to a late Mississippian formation in the paper entitled "Origin and Significance of the Mauch Chunk Shale," in which he concludes that "In the anthracite region, more surely in the southeastern and eastern portions, the whole formation [which is about 3000 feet thick], from top to bottom, was a subaerial delta deposit laid down under a semiarid climate." The nearest approach to-day to a similar area is the highly arid Punjab region near the base of the Himalayas and the lower plains of the Indus River. "These comparisons, while not intended to convey the idea that the Appalachians were ever of Himalayan magnitude, are suggestive of a more massive range of mountains and a wider land area to the eastward of the Pennsylvanian geosyncline than is customarily thought of as existing in Upper Devonian and Carboniferous times."

Having seen much of the Carboniferous of eastern Pennsylvania, Barrell had asked himself, "To what extent have the tectonic movements and climatic variations caused the great contrasts seen here in the Lower and Upper Carboniferous formations?" To solve this problem, he took up in detail the principles that have to do with the relations between climate and terrestrial deposits and published his results in a paper bearing that title. He writes: "The environment of the lands may be classified into three fundamental and independent factors—the relations to the surrounding seas, the topography which forms their surfaces, and the climates which envelope them; each of major importance in controlling the character of the lands." Fundamental are the relations of the continental fluviatile deposits to the climates, and they may be successfully used in determining those of the geologic past. "This is exclusive of the significance of salt and gypsum deposits on the one hand or of glacial deposits on the other, which are of course universally recognized, but these are the marks of climatic extremes."

The first part of the paper under review has to do with the relations of sediments to regions of erosion. It deals with the relation of physiography to erosion and the consequent supply of waste as sediments to the formations. Then he takes up the relations of sediments to regions of deposition, and finally the relations of climate to fluviatile transportation. These parts lead to the conclusion that "Climate is a factor comparable to disturbances of the crust or movements of the shore-line in determining the nature and the variations in the stratified rocks of continental or offshore origin, thus playing a part of large, though but little appreciated, importance in the making of the stratigraphic record."

Along with many other things, Barrell finds that "While the varying powers of erosion and transportation are delicate stratigraphic indicators of *climatic fluctuations,* the chemical and organic control accompanying the deposition are the more secure indicators of the *average climatic conditions.*"

Finally, what was the origin, environment, and significance of the conglomerate and sandstone formations intercalated between others of different nature? Barrell's answer is that these coarse materials have three origins: first, marine conglomerates and sandstones; second, tectonic conglomerates and sandstones; third, climatic conglomerates and sandstones.

"Changes in volume of ocean waters, earth movements, and atmospheric activities are the three mixed and fundamental causes by which the three classes of deposits become possible, but the records which they embody are largely distinct and independent. By separating conglomerates and sandstones into these three classes, the sedimentary rocks, therefore, present a threefold record, the marine conglomerates giving that of the variable relations of land and sea; the tectonic conglomerates, the record of variable vertical uplifts; the climatic conglomerates, the record of variable temperature and rainfall."

In 1910, Professor Sherzer published a valuable paper on the "Criteria for the Recognition of Various Types of Sand Grains." He found seven types, and in the application of the ascertained principles to the Sylvania sandstone, he came to the conclusion that it is of eolian origin. In a review of the paper in the same year, Barrell thinks this conclusion is not warranted, because as yet too few sands, modern and ancient, have been studied enough in detail.

Barrell's next study was on "Some Distinctions between Marine and Terrestrial Conglomerates," the gist of which he presented before the Geological Society of America in 1908. A half-page abstract appeared in the Society's *Bulletin* and in *Science* in 1910, but the paper as a whole was not printed until 1925. Its conclusions are as follows:

The truly terrestrial forces produce vastly more gravel, pile it in thicker formations, spread it far more widely, and provide more opportunities for accumulation than do the forces of the marine littoral areas. Conglomerates are, therefore, dominantly of terrestrial origin; they are as characteristic of continental deposits as the limestones are dominantly marine.

The present volume rates of denudation Barrell finds to be, for marine areas, between .02 and .10 cubic miles per year; while fluviatile denudation yields as marine or as continental deposits 1.50 to 3.00 cubic miles per year. In other words, the total annual erosion is from about 3.00 to 6.10 cubic miles.

Marine denudation attains its "highest absolute and relative value at times of great marine transgressions. . . . Its absolute value may readily have been twice the present amount, and its value relative to subaerial denudation may have attained even twenty times the present ratio."

In regard to gravels, he says: "The gravels supplied by fluviatile erosion are some tens of times greater in quantity than the gravels produced by the erosive action of the sea."

Concerning the distribution of marine gravels, Barrell's conclusions are: "On open coasts with fixed shorelines marine gravels commonly range from about 1 fathom above high-water level to 4 or 5 fathoms below. They are kept against the coast and seldom extend more than from 1 to 3 miles from shore. . . . Marine gravels . . . may under exceptional circumstances, extend to ten times these limits."

Marine conglomerates rarely attain a thickness of 100 feet, and even this depth is exceptional and local. On the other hand, terrestrial conglomerates are often many hundreds and sometimes thousands of feet thick.

"Rivers commonly move gravels down descents of hundreds of feet from their regions of origin and along horizontal distances of tens of miles. . . . Under favorable conditions, moreover, rivers may sweep gravels from far inland mountains to the margin of a continent and down descents of thousands of feet. Consequently, rivers, as agents of gravel distribution, may be a hundred times more effective than the shore activities."

"In conclusion, it is seen that gravels of either marine or terrestrial origin require stable conditions for their development. They are local and not widely distributed formations. Marine gravels are most restricted, since they are limited to the margin of the sea. River gravels, on the other hand, may occur over all parts of the lands, but do not tend to attain the sea. Finally, in order that gravel may remain as conglomerate formations, either of terrestrial or marine origin, it must be progressively buried below the zone of erosion."

Having finished the paper on conglomerates, Barrell now sought out a thick and unfossiliferous conglomerate-sandstone series whose age relations were obscure. Such a series he found in the southern Appalachians, and upon this he made another study that was published during 1925. The conglomerates, sandstones, and slates of the Ocoee and Chilhowee groups of Tennessee, North Carolina, and Alabama have long been a stumbling block in correlation, because it is only near the top of the thick series that fossils have been found. On the basis of these fossils, Keith finally referred all of the Ocoee and Chilhowee to the Lower Cambrian. Barrell discussed the many formations of this series, aggregating between 9000 and 13,000 feet in depth, and concluded that the lower part, with a maximum thickness of 7500 feet, is of terrestrial origin. The middle formations, with a thickness of 3400 feet, are in part at least a terrestrial deposit, though a part is probably estuarine. The remaining 2700 feet are entirely of marine origin.

As to the nature of the geosyncline in which these Ocoee-Chilhowee deposits were laid down, he concludes that it lay between mountains, had a very irregular bottom, and that its crustal subsidence shifted at first from place to place. Most of the deposits came from the areas of maximum deposition, tens of miles away. In regard to the geanticline that supplied the Ocoee-Chilhowee formations, he thinks that at the close of the Proterozoic an Alpine-like mountain system stood on what is now the Piedmont Plateau of the southern Appalachians. Finally, late in Lower Cambrian time, the region passed into topographic old age. The climate, he holds, was at first cool, with moderate rainfall, and later considerably warmer.

In 1912, in continuation of his studies of sedimentary formations, Barrell published the paper entitled "Criteria for the Recognition of Ancient Delta Deposits." He defines a delta as "a deposit partly subaerial built by a river into or against a body of permanent water." This study concerns the detailed structures of deltas, the physiography of the lands that furnished the detritus, and the cyclic nature of the erosion of the rivers and therefore also of the delta accumulations. It is a difficult study because of the great variability in the extent of deltas, in the character of their sediments, in the size and streaming power of the river or rivers that bring the material, and finally in the wave and streaming forces of the water body and the depth of the water in which and in front of which the deltas are laid down.

In 1913-1914 followed the application of the criteria of the previous paper to the Upper Devonian delta of the Appalachian geosyncline. This is one of Barrell's best pieces of work, and a very philosophic one, for it brings out the relations of the Appalachian delta, both to the interior sea and to the extensive eastern land Appalachia and the Atlantic Ocean beyond. The volume of this extensive delta Barrell computed at about 16,500 cubic miles for Middle Devonian and 63,000 cubic miles for Upper Devonian time. "This is an impressive measure of the volume of the adjacent land which was eroded in Upper

Devonian times. But it is a minimum measure, since that part of the rocks which was taken into solution was carried farther away, and of the mechanical sediments it represents only that part which was carried westward into the trap of the geosyncline."

This Devonian delta implies a much greater Appalachia than is usually assumed, and one which must have exceeded the present Sierra Nevada in elevation. Barrell thinks that this old land was not confined to the limits of the present continental shelf, but probably extended out into the Atlantic for an unknown distance where there is now deep ocean. Accordingly, great parts of eastern Appalachia must have been fragmented and sunk into the depths of the Atlantic during Mesozoic time.

As early as 1905, Barrell began to ask himself, What were the geographic and climatic conditions which controlled the nature of the Old Red Sandstone deposits? In 1906 he wrote out his views but withheld them from printing, thinking that he and the present writer would find means of visiting Scotland. As this opportunity did not come, he presented his ideas in 1916 in the paper "Dominantly Fluviatile Origin under Seasonal Rainfall of the Old Red Sandstone." A copy of this paper was sent to Professor T. G. Bonney of University College, Cambridge, England, and his letter of thanks to Barrell opened with the word "Eureka!" Truly, here is the correct explanation of the origin of the Old Red Sandstone.

"The central conclusion reached in this paper is that the Old Red Sandstone formations were not deposited in lakes or estuaries, nor are they of desert origin." They are "river deposits accumulated in intermontane basins," "exposed to air in times of drought," and "similar to the basin deposits of the western United States laid down in the Tertiary period between the growing ranges of the Cordillera." There was "an alternation of seasons of rainfall and drought—a climate with an arid season, but not an arid climate." "The Great Valley of California may therefore in the present epoch, both in physiography and in climate, be cited as a striking illustration of the nature of the Old Red Sandstone basins."

In 1915, R. W. Sayles presented a paper on "Banded Glacial Slates of Permocarboniferous Age, showing Possible Seasonal Variations in Deposition." In discussing this paper, Barrell pointed out that he had noticed similar stratigraphic banding in argillites associated with the oldest of all known tillites, those of the Huronian of Ontario. He says: "At the south end of Cobalt Lake occurs a thick bed of argillite delicately banded, indicating rhythmic deposition. The bands are grouped in series which show larger rhythms. If the bands are annual, the rhythmically recurring groups show climatic fluctuations covering periods of years. . . . The association of these banded argillites with iceberg deposits and ground moraine indicates, therefore, the existence of summer melting and winter freezing during the Huronian glaciation."

In 1908, Professor Schaeberle published his conclusion that most of the postulated theories of geological climates are upset by his theory of temperature of space, that is, they are invalid because they are based upon an adopted value for the temperature of space which is too great by nearly three hundred degrees of the centigrade scale at the earth's distance from the sun." To this sweeping dictum Barrell, in a short notice in *Science,* "Schaeberle and Geological Climates," replied that ancient climates "are based not upon considerations of the temperature of space, but upon detailed studies of the geological record." "Manson's hypothesis of an earth self-heated and protected by a cloud envelope until the Tertiary, which Schaeberle considers that he has demonstrated as a true theory, must be regarded as in no measure adequate to explain the facts."

Paleoclimatology as derived from the nature of the sediments was Barrell's special field, and he was the recognized leader in it. His article on the relation between climate and terrestrial deposits (1908), discussed more fully on page 16, "traces," according to Willis, "the complex variations of temperature and rainfall and their effects upon sediments with such keen analytic power, such wealth of illustration, and such logic as to lay firmly the foundations of interpretation of terrestrial stratigraphy in terms of climate."

## PIEDMONT TERRACES OF THE NORTHERN APPALACHIANS

While an undergraduate student at Lehigh, Barrell became interested in the physiography of the highlands of New Jersey and Pennsylvania. He had studied Davis' works, but on account of the peculiarities of the wind gaps and the rivers that flow through the ridges with which he was familiar, he concluded that much of the area must have been beneath the sea and covered by sedimentary deposits. This was in opposition to the prevalent opinion that the present rivers were incised in the "Cretaceous peneplain." His views were formulated for the first time in his Lehigh thesis of 1897, but it was not until 1913 that he presented the matter in more mature form before the Geological Society of America. The assumed Mesozoic terrestrial peneplain of southern New England he finally showed to be in reality of marine origin and "stairlike or terraced in its character, facing the sea." It was this study that was absorbing his last years, and his death made impossible what would have been his *magnum opus*. In 1915 he demonstrated his theory in the field before the New England Intercollegiate Geological Association, as leader of a characteristically well planned and carried out excursion to the critical areas in Connecticut, in the course of which he met with equanimity the frequent questions and objections of a party which included Davis, Johnson, Miss Bascom, and many others with vigorous ideas of their own on the subject.

Regarding this intricate and far-reaching study, Barrell left a mass of manuscript notes and drawings, which H. H. Robinson put into order for publication during 1920. Barrell had not, of course, gone far enough with his studies to develop his ideas completely, but he laid the foundations for others to build upon. The subject is a fascinating one, and all the more so since Barrell's views are decidedly at variance with the generally accepted views of geologists, both as to the number of erosion cycles and their ages. The following is taken from Robinson's editorial review of Barrell's work:

"The physiographic history of the Appalachian region has rested on the recognition of a topographic plane of reference, commonly known as the Cretaceous peneplane, above which rose older residual masses, below which were locally cut secondary topographic levels of Tertiary age representing temporary stillstands of the land following periods of uplift, and on the outer margin of which rested the great unlithified series of Mesozoic and Neozoic sediments. The underlying assumption was that all peneplaned surfaces were the result of fluvial denudation and that remnants of all remain so little reduced as to permit the former surfaces to be restored with assurance.

"In most parts of the province three cycles of peneplanation were recognized and correlated in a general way, as the Cretaceous, the early Tertiary, and the late Tertiary. In some localities an older erosion surface, the Jurassic peneplain, was recognized."

Barrell held, at least for New England, that the various terraces are "initially the result of marine denudation," that most of them are of post-Miocene age, and "that the terraces could be restored from their existing remnants." Gradually he came to the conclusion that there were eleven such benches, all of marine origin. "The names, elevation [in feet] of the inner restored margins, and the age of the terraces are as follows:

| | | |
|---|---|---|
| "Becket | 2450 | Cretaceous |
| Canaan | 2000 | Cretaceous |
| Cornwall | 1720 | Oligocene |
| Goshen | 1380 | Pliocene |
| Litchfield | 1140 | Pliocene |
| Prospect | 940 | Pliocene |
| Towantic | 740 | Pliocene |
| Appomattox | 540 | Pliocene |
| New Canaan | 400 | Pleistocene |
| Sunderland | 240 | Pleistocene |
| Wicomico | 120 | Pleistocene" |

Robinson concludes: "A careful study of the profile and maps both topographic and geologic, coupled with some acquaintance with the region, has left the definite impression that Professor Barrell's conclusion as to the marine origin of the terraces below the Cornwall is well taken." The two older terraces, however, Robinson regards as of early Tertiary origin rather than as of Cretaceous time.

## RHYTHMS AND GEOLOGIC TIME

Barrell was one of the participants in a symposium on the interpretation of sedimentary rocks at the Albany meeting of the Geological Society of America in 1916. Here he presented a part, but only the smallest part, of a study on "Rhythms and the Measurements of Geologic Time." This is his most important work, and will remain a source of information and stimulation to research along several lines of philosophical thought.

He had long been attracted by the cycles of sedimentation: "Nature," he says, "vibrates with rhythms, climatic and diastrophic." The viewpoint of the six parts of the study is geological, with the emphasis on the pulsatory nature of uplifts and subsidences, though the evidence furnished by radioactivity is thoroughly reviewed. Part I treats of the rhythms in denudation, and shows that "erosion is essentially a pulsatory process" and that "a single rhythm is the erosion cycle; and small partial cycles are superimposed on larger." Here then is developed the hypothesis of compound rhythms. This part leads to the conclusion that the present rate of denudation is high, in fact, "very much greater than the mean for geologic time." Part II deals with rhythms in sedimentation, and shows that sedimentation "is not a continuous process, even during a stage of crustal depression." Therefore the stratigraphic record is replete with "breaks" of varying time lengths, the non-seeable greater disconformities and the lesser but more numerous diastems.

J. M. Clarke in "L'Île Percé" says: "My lamented friend, Joseph Barrell of Yale, wrung the music from a wall of rock of water-laid sediments, by showing how the record, if correctly read, is a succession of rests and beats. The quiet waters lay down their deposits in uninterrupted conformity, till a storm wave of short length and greater height breaks them. The high note passes and subsides into the lower beat, again recorded in unbroken deposits. Slowly the sea bottom is raised above the waves and the hardened sands and clays are worn jagged and rough by the rains and streams; slowly the land sinks beneath the waters and on its uneven strata are again laid the even deposits of the quiet sea. Thus about him everywhere, if one will read and listen, lie the symphonies of the rocks."

Part III treats of the estimates of time based on geologic processes, on erosion, sedimentation, hypothesis of compound rhythms, amount of oceanic salt, and on the loss of primal heat. In this presentation we get a more adequate idea of the quantitative lengthening of geologic time. "Measurements of Time based on Radioactivity" is the subject of Part IV, which is a worthy associate of Holmes's "Radioactivity and the Measurement of Geological Time," published in 1915. Finally, in Part VI, "Convergence of Evidence on Geologic Time and its Bearings," the geological and physical arguments are bound together into a unity, resulting in the conclusion that at least 550 million, and a maximum of 700 million, years have elapsed since the beginning of the Cambrian. This is, moreover, less than one half of geologic time, for the Laurentian or post-Ladogian granites, the oldest great invasions of igneous magmas into vast thicknesses of sedimentary formations, have an age as great as 1,400,000,000 years. "Combining the indications regarding the present high rate of denudation with the evidence of the halting and discontinuous nature of past deposition, it is seen that geologic time is certainly much longer—perhaps ten or fifteen times longer—than the estimates based on strictly uniformitarian interpretation." This paper, Holmes (1925) says, is "the most careful study of geologic time yet published."

Harlow Shapley, the astronomer, accepts Barrell's geologic time estimates, and says: "We may study the stars, indeed, with the aid of fossils in terrestrial rocks, and acquire knowledge of atomic structure from the climates of Precambrian times." "In the growth of our concepts of the age of the earth, Barrell's discussion is likely to mark an epoch because of its consistent carefulness, its great expansion of geologic time beyond the commonly accepted limits, and its decided rebellion against the stringent limitations set by Kelvin and later physicists."

## ISOSTASY

Barrell's most philosophic works have to do with isostasy and the genesis of the earth. It was in 1904 that he began to write on the former subject, in a review of T. M. Reade's book, "The Evolution of Earth Structure." Two years later he wrote a review of J. F. Hayford's "The Geodetic Evidence of Isostasy," giving also a brief historical review of the place of this subject in geological literature and of the problems upon which it bears. Finally, in 1914, he reviewed briefly the status of the hypothesis of polar wandering, concluding that "Closer examination tends to cut down more and more even those moderate limits of polar migration set by Darwin. It would appear that the assumption of polar wandering as a cause of climatic change and organic migrations is as gratuitous as an assumption of a changing earth orbit in defiance of the laws of celestial mechanics."

During the years 1914 and 1915, Barrell published in the *Journal of Geology* a series of eight papers that were later collected and bound in one volume under the title "The Strength of the Earth's Crust." The first part of this series of articles treats of the geologic tests of the limits of strength. In Parts II and III is discussed the "Regional Distribution and Influence of Variable Rate of Isostatic Compensation." Part IV deals with the "Heterogeneity and Rigidity of the Crust as Measured by Departures from Isostasy," while Part V is on "The Depth of Masses producing Gravity Anomalies and Deflection Residuals." Part VI is devoted to the "Relations of Isostatic Movements to a Sphere of Weakness—the Asthenosphere," and Part VII to "Variation of Strength with Depth, as shown by the Nature of Departures from Isostasy." The final part has to do with the "Physical Conditions Controlling the Nature of Lithosphere and Asthenosphere."

This work at once placed Barrell high among geodesists and geologists. Willis says: "Barrell's analysis covers every part of the subject exhaustively, dissociates all its elements, weighs them, and recombines them. It is the product of extraordinary industry, activity and thoroughness." Arthur Holmes writes of it as a "remarkable series of papers, which is worthy of the most careful study, and constitutes a valuable and stimulating contribution to terrestrial dynamics." According to Pirsson, "They constitute probably the most serious and profound discussion, which has yet been attempted, of the facts which are known and of the theories which have been deduced from them, concerning the strength of the earth's outer shell."

The year of Barrell's death, there simultaneously appeared two papers, "The Nature and Bearings of Isostasy," which is a non-technical summary of the subject, and "The Status of the Theory of Isostasy." These papers, which may be regarded as Barrell's mature views on isostasy, are reviewed in *Nature* for February 12, 1920, and from that review the following excerpt is quoted: Barrell here maintains "that surface inequalities of contour and mass are accompanied by inverse inequalities of density beneath the surface, so that at a depth of about 120 kilometers equal areas have equal masses superposed." He "contends that over limited areas there are large deviations—amounting to 1000 feet over an area 200 miles in diameter (about 3°), or even more. He regards the upper part of the earth's crust as sufficiently strong to sustain uncompensated loads of this amount, the vertical magnitude of the departure being, of course, inversely proportional to its areal extent; it can thus support individual mountains or limited ranges, as well as erosion features of considerable magnitude, such as the Nile and Niger deltas. Under greater and more widely extended loads, however, the crust is supposed to bend in gentle curves involving but little crustal stress; this bending is accompanied by yielding in a lower, weaker layer, which brings about isostatic compensation."

Barrell's work on isostasy, Bowie states, "was far-reaching and thorough, and threw much light on the relation of isostasy to geology. In fact, Barrell did more, in my estimation, to bring the geodesists and geologists together in the science of isostasy than did any other investigator."

## GENESIS OF THE EARTH

In 1907, Barrell reviewed W. H. Pickering's paper, "The Place of Origin of the Moon." This place the latter thought to be the Pacific Ocean, thus giving rise to that basin. Barrell shows that oceanic basins could not have arisen in this way.

Chamberlin's very important book, "The Origin of the Earth," appeared in 1916, and Barrell was looking for it. After reading it, he wrote a five-page review which was printed in *Science* for August 18, 1916. "The subject is vast," he says, "and the evidence on many aspects is somewhat vague. A variety of subhypotheses could be raised for comparison." Regarding the size of the planetesimals, Barrell states: "It seems a debatable question to the reviewer if such a large proportion of the added material was necessarily dust-like and capable of being distributed by the primitive atmosphere and ocean. Upon the mean size of the incorporated units various subhypotheses of consequences may be built up."

Chamberlin's hypothesis of juvenile shaping "is, of course, like the other steps in the development of the planetesimal hypothesis, dependent upon the basal postulates. It is not clear that earth-strains due to the causes invoked could initiate such a primary segmentation . . . in fact, calculations on the stresses which the reviewer has made to test this subhypothesis pointed to quite a different method of yielding. The distribution of continents and oceans does not accord very closely with it, and the evidence of isostasy does not indicate that the density differences between continents and ocean basins reach below the outer fiftieth of the earth's radius."

In Barrell's opinion, however, "The Origin of the Earth" is "a notable constructive addition to thought upon this fundamental subject. . . . The names of Chamberlin and Moulton must rank high among those scientists who have dealt constructively with that vast, vague and remote problem—the Origin of the Earth."

When Chamberlin's book appeared, Barrell was getting ready for a lecture to be delivered on November 23, 1916, before the Yale Chapter of the Sigma Xi, the introductory one in the course on "The Evolution of the Earth and its Inhabitants" (later issued in book form by the Yale University Press). The manuscript finally grew far beyond the content of his lecture, and eventually appeared in part in three different places: as the first chapter in the book resulting from the lectures; as Chapters

VIII, IX, and XI in the first edition of Schuchert's "Historical Geology"; and in the *American Journal of Science* during 1927.

In the summer of 1916, Barrell wrote on the "Significance of the Equatorial Acceleration in the Sun's Rotation." This short paper will not be published, but is preserved for future reference in the library of Peabody Museum, Yale University. It was followed by an extended paper entitled "Geological Relations of Earth Condensation and Resulting Acceleration in Rotation," which was published in 1925 and 1926. He begins with the questions: "(1) Is the earth smaller now than it was in the early geological periods? If so, what has brought about that condensation? (2) Has tidal retardation by moon and sun effectively increased the rotation period of the earth since the Archeozoic, or has this been a geologically negligible factor? (3) Has condensation produced an acceleration in rotation? If so, how much more oblate would the earth become? (4) Could such a change of figure be recognized by a change of sea-level and to what amount, or would it be inappreciable in effect? (5) What distortions would be given to the crust and would these be wholly masked by the orogenic and epeirogenic movements due to other causes? (6) How would the stresses due to change in figure be distributed through the earth? Where and how would failure occur? (7) Are regional joint-systems related to the planetary stresses? (8) Lastly, can these forces have reached a higher order of magnitude during the formative period of the earth, and if so, may they have had an influence in determining the arrangement of the larger features of the earth?"

His conclusions are divided into two groups. On the one hand, so far as stresses in the earth's body are concerned, those due to change of oblateness would appear to be wholly submerged beneath those due to change of volume. It is difficult to see in these results either a basis for a segmentation of the earth into great conical sectors, or a recognizable cause for the shifting of epeiric seas. On the other hand, it appears probable that planetary strains occur in the outermost shell of the crust, the zone of fracture, which may constitute one of the major factors in determining the nature of regional joint systems. These stresses may also coöperate with local forces in helping to determine the trend of normal fault systems.

"The paper is written chiefly on account of its suggestiveness toward further work, rather than because of any finality in conclusions. In a field where so little is directly known, as in that of the deep interior of the earth, the method of multiple working hypothesis must be assiduously cultivated, and although the present analysis favors one group of hypotheses, it should not be regarded as ruling others out of further consideration."

Finally, Barrell wrote "On Continental Fragmentation and the Geologic Bearing of the Moon's Surficial Features." This paper, published in 1927, includes his ideas of how land bridges like western Gondwana across the Atlantic may be dragged into the depths of the oceans. "The outer crust of the earth," he says, "granitic in its upper part and somewhat more basic at depth, is held to have a thickness of from 50 to 75 miles. It is very strong, and is marked by broad variations in density amounting to as much as 5 per cent, and by more local variations up to 10 per cent, these differences corresponding to the broader relief of the earth's surface. Below this lies a thick, hot, basic, rigid yet weak shell, the asthenosphere, or sphere of weakness. The problem of the origin of the ocean basins and the continental platforms consequently resolves itself into one of the origin of the density differences in the lithosphere and the maintenance of the heated and weak condition in the asthenosphere."

"The small content of radioactive elements in the basaltic shell or asthenosphere below the granitic crust of the continents would then supply that slow increment of heat which is necessary to generate new molten rocks. The granitic shell loses its excess heat by conduction to the atmosphere, but the asthenosphere is so deeply buried that its heat can not escape, but must slowly transform some of the solid rock into liquid form. Reservoirs of molten rock gather until their mass, combined with their decreased density in the fluid form, enables them to work their way into and through the lithosphere and demonstrate their existence in igneous activity at the surface of the earth. The magma which thus comes from the greatest depth and in greatest volume would, because of the initial density stratification, produce a notable increase in the density of the outer crust. In order to reëstablish isostatic equilibrium, such a region must subside."

"Most American geologists hold strictly to Dana's theory of the permanency of the continents and ocean basins, whereas European workers in general stand by the older view that ocean basins are broken-down portions of the granitic shell. We may also include this grander process of crustal change under the term of continental fragmentation. Great intercontinental troughs, such as the Red Sea and the Caspian, are thought to have been made in later geologic times by fracture of their margins and subsidence of their floors. The writer accepts the European view, since, in spite of its difficulties, it yet accounts for many geological relationships. If continental fragmentation is real, it has a strong bearing upon the general problem of the origin of ocean basins, for the progress of fragmentation is in reality a continuation of the formative process. Through fragmentation the margins of the continents break down into the oceanic depths and enlarge them, and at the same time diminish the areas of the land."

Finally: "Smoothing out the crustal oscillations connected with periods and eras, it appears that a great cycle of progress has run through earth history. High and wide lands marked the Archeozoic and Proterozoic revolutions; fragmentation was apparently widening the earliest ocean basins and lowering the ocean levels, but the juvenile waters from the accompanying igneous intrusions reëlevated them. Then came a long time, from the early Paleozoic to the close of the Devonian, during which the oceans rose and repeatedly spread over the lands. Since the later Paleozoic, however, the ocean level has tended to sink, and fragmentation appears to have gained on the accessions of juvenile water. . . . But the lands have been kept high above the increasing waters only by the breaking down of portions of their areas into ocean basins. . . ."

Barrell then takes up a study of the moon's surface as known to astronomers and ends the paper of 1927 as follows: "Thus the study of the earth's small sister planet supports the general hypothesis that the ocean waters as well as the ocean basins have arisen through igneous activity, and that fragmentation of the original crust has dominated the moon as well as the earth throughout geological time."

In the Sigma Xi lecture mentioned above, Barrell modified the Chamberlin hypothesis of slow growth resulting in a cold earth to one of quick growth through planetoids the size of asteroids, a postulate which necessitates a molten earth.

## PALEONTOLOGY AND EVOLUTION

As Barrell also taught Biology at Lehigh and Historical Geology at Yale, it was but natural that he should be interested in Paleontology. This side of his activity is little known away from Yale, but his colleagues there were often made aware of his deep interest and knowledge along this line. He never was concerned with species and genera, nor with classification, but to him the bony structures of vertebrates were mechanisms and he tried to see in them the effects of the operation of the laws of mechanics. And through his insight into Paleoclimatology, he tried to discern the effects of changing environment as the most important cause of organic evolution.

While studying the nature of the Old Red Sandstones, and what they show as to their climatic environment, Barrell became deeply interested in Chamberlin's ideas regarding the probable habitats that gave rise to the fish-form, and to lungs. His ideas on these subjects culminated in 1916 in a paper entitled "Influence of Silurian-Devonian Climates on the Rise of Air-breathing Vertebrates." The problems he seeks to answer are two: "first, as to the environment in which fishes developed; second, the changes in the environment and the associated organic responses which brought forth amphibians from fishes. It is the solution of the second problem which is here especially sought."

"It is shown to be probable that fishes arose in land waters. As such they constituted primarily a river fauna." It is in the Middle Devonian that the fishes "first really begin to conquer the ocean and its former rulers." On the other hand, in the fresh waters of this time fishes abounded in greater variety than in the seas. In the Upper Devonian, crossopterygian fishes had risen to a dominant place, and they were adapted to living in warm climates marked by alternation of wet and dry seasons, the kind of environment that gave rise to the amphibians. "The warm and stagnant waters of the dry season compelled those fishes which should survive to make larger and larger use of air."

"The evidence is regarded as strong that the air-bladder was originally developed as a supplemental breathing organ, although in modern fishes it has been mostly diverted to other uses." Barrell also quotes this significant passage from W. D. Matthew: "The evolution of land life in adaptation to recurrent periods of aridity supplies a satisfactory background of cause for the whole evolution of the higher vertebrates," to which he adds, "Climatic oscillation is a major ulterior factor in evolution."

The study of the natural environment as recorded in the sediments that also entombed the fossils led naturally to the work entitled "Probable Relations of Climatic Change to the Origin of the Tertiary Ape-Man." Here we again read that climatic variation is the most fundamental evolutionary factor for terrestrial life. This was especially true for the Pleistocene, when the land biotas "have come and gone at the command of climatic change. Those animals which were trapped on the northern sides of mountain ranges or water barriers were remorselessly exterminated by the waves of advancing cold; those which could escape to the south returned with milder climates, but changed in assemblage." Barrell held that man was brought to his present high physical and mental state not as the "mere product of time and life," but that he is "peculiarly a child of the earth and is born of her vicissitudes." "The progress of life on the earth has been highly favored, consequently, by the rhythmic pulses of diastrophic and climatic changes which have remorselessly urged forward the troop of living creatures. The progress of organic evolution has depended upon a series of fortunate physical events, conditioned in the internal nature of sun and earth, rather than the byproduct of mere life activities as expressed in orthogenesis through long periods of time. Evolution is in no sense an inevitable consequence of life, and the compulsion of climatic change has been more than once a fundamental factor in the age-long ascent from protozoan to man."

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(In files of the U. S. Geological Survey.)

Description of the Housatonic quadrangle.

# BIOGRAPHICAL MEMOIR

OF

# CHARLES EMERSON BEECHER.

## 1856–1904.

BY

## WILLIAM HEALEY DALL.

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READ BEFORE THE NATIONAL ACADEMY OF SCIENCES
NOVEMBER 16, 1904.

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# BIOGRAPHICAL MEMOIR OF CHAS. EMERSON BEECHER.

Charles Emerson Beecher, eldest son of Moses and Emily (Downer) Beecher, was born in Dunkirk, New York, October 9, 1856.

The mother of Moses Beecher was a Dawson, originally from England. On the Emerson side, the great-grandfather of Charles, Richard Emerson, was from Spofford, New Hampshire, and his wife was Mary Gorton, a direct descendant of Samuel Gorton, of Rhode Island. They moved to Otsego county, New York, in 1749.

Moses Beecher was a banker, and is remembered as a courtly gentleman of the old school, a man of education and refinement. He and his wife were considered persons of more than ordinary cultivation and attainments. Five children, four boys and a girl, were born to them, of whom one brother survives in California.

In the early childhood of Charles his parents removed to Warren, Pennsylvania, where the boy attended private grammar and the public high schools. The surroundings were favorable, the rocks of the vicinity rich in fossils, and at the age of twelve years he began making a collection of the local fossils. Perhaps, as he was always delicate, his parents may have encouraged him as a means of keeping him as much as possible in the open air. At all events, he became much interested, and amassed from the Chemung and Waverley formations of Warren a choice and extensive collection. These tastes soon led him to extend his studies to the minerals and recent shells, in which he always remained interested.

Later he took the scientific course at Michigan University, receiving in 1878 the degree of B. S. from that institution. The late Prof. James Hall, of Albany, kept a watchful eye on all students and collectors of fossils, and after graduation, young Beecher went to Albany almost immediately, where he was engaged as assistant in the New York State Museum directed by

Professor Hall, and affording unrivaled opportunities for the study of American paleozoic invertebrates. During the ten years spent here by young Beecher he not only became proficient to a remarkable degree in knowledge of the New York faunas, but, having a natural facility in mechanical matters and the use of tools, he became an exceptionally fine preparator of fossils, and always enjoyed the process of disentangling a complicated fossil from its matrix, or the revelations of the saw in making serial sections. Some of the preparations of groups of trilobites left by him in the State Museum are marvels of well-directed and successful effort. In such things he took the pride of a successful craftsman who knows that his work is good.

His first scientific papers were written in coöperation with others, and treated of the recent mollusks. After going to Albany he continued to collect and study the local fauna. These, together with material collected at Warren and near Ann Arbor, or obtained by exchanges, amounting in all to about twenty thousand specimens, he gave to the New York State Museum in 1886 and 1887.

Beside work on the collections at Albany he rendered, according to Prof. James Hall, important assistance to that gentleman in the preparation of his great monographs of the different groups of invertebrates from the New York rocks, especially the Mollusks, Polyzoa, and Corals. These works were printed by the State of New York, and in the prefaces ample acknowledgments are made of Beecher's services.

Always skillful as a draftsman, he added to his small salary from the State by making drawings for professional men at Albany, and most of his papers were illustrated by his own hand. His vacations were spent at localities where collections could be made, especially the richly fossiliferous beds of the Helderberg Mountains, near Albany, New York. Of his collections here Professor Jackson remarks:*

"Indian Ladder," in the Helderberg Mountains, was always a favorite and fertile spot for him, dating back to his Albany days. It is one of the most beautiful and picturesque regions in the Helderbergs. He collected there slabs of limestone containing fossils which were silicified in the most perfect condition for development by etching with acid. From such materials he obtained specimens of surpassing beauty and scientific interest. Beside adult fronds of Bryozoa, Brachiopoda, Crustacea, and other fossils in most perfect preservation, he obtained minute embryos and small species in large numbers in literally wonderful condition of perfection. Young *Bilobites* half a millimeter in length, young *Acidaspis* 0.83 millimeter, and *Arges* 1.15 millimeters long, both of the latter so perfect that he figured them from both the dorsal and the ventral aspects; young *Pleurodictyon* consisting of the initial cup alone, and also others with the first lateral buds.; young *Bryozoa* showing initial chambers. Such material, selected with infinite care and patience, formed the basis of a number of papers by Beecher and others.

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*American Naturalist, vol. xxxviii, No. 450, p. 411.

At this period Beecher published independently a paper on Phyllocarida, a group in which he never lost interest, from material collected by him at Warren, Pennsylvania; and several papers on the recent Rissoidæ. His most important work of this period was based on Brachiopoda obtained from the clays of Waldron, Indiana, in which he was associated with John M. Clarke. This paper is one of the first on the development of Paleozoic Brachiopoda, and opened up several new lines of investigation.

In 1888 Prof. O. C. Marsh, of New Haven, induced Beecher to accept the position of Assistant in Paleontology at the Peabody Museum of Yale University, though for a time he was also named Consulting Paleontologist to the Museum at Albany, and returned there from time to time in connection with the duties of this honorary position. He also pursued his studies at Yale, under Dana, for the degree of Ph. D., which was conferred upon him in 1889, his doctoral thesis treating of the Brachio-spongiidæ, a group of fossil sponges of which the Yale Museum has an unusually fine series. Owing to the illness of Professor Dana, in 1891, Beecher took charge of the classes in Geology during that and the following year, when he was made Instructor in Paleontology, and later Assistant Professor of Paleontology, becoming in 1897 Professor of Historical Geology and a member of the Governing Board of the Sheffield Scientific School of Yale University.

Professor Marsh recognized Beecher's ability and appreciated his loyalty as assistant in the Museum, which on the Paleontological and Geological side Marsh effectively controlled during his lifetime. On Marsh's death, in 1899, Beecher succeeded him as curator of the geological collections, and was made a member of and secretary to the Board of Trustees of the Museum. He then undertook to arrange, develop, and place on exhibition the Marsh collection of fossil vertebrates. This work was done under his direction, though he personally had much to do with the large mounts of *Claosaurus* and *Brontosaurus,* the former of which he has described at length in a paper published by the Connecticut Academy in its Transactions.

In June, 1899, Beecher gave his large and very valuable collection of fossils to the Peabody Museum, as he expressed it, "in grateful recognition of the honors and favors conferred upon me during my connection with the University." These collections comprised over 100,000 specimens and about five hundred types, which had served as a basis for publications by the States of New York and Pennsylvania and various scientific periodicals. The material was chiefly from the Devonian and Lower Carboniferous of the two States mentioned, and represented the private labor, outside of his official working hours, for some twenty years.

"Already interested in studies of the development of organisms from his work on the development of Silurian brachiopods, in 1889 Beecher became deeply interested in the late Professor Hyatt's methods of work—the application of the principles of stages in development, acceleration, parallelism, and dynamic genesis to the unraveling of the genealogical relations of living and fossil animals. Bringing to this work his large and intimate knowledge of species and the structure of fossil types, Beecher entered into this field with characteristic energy and became a leader of the Hyatt school. Beecher's reputation as an investigator will rest chiefly on the rich results he obtained in the critical, painstaking application of those fruitful principles that Professor Hyatt labored so long to establish."*

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* R. T. Jackson in American Naturalist for June, 1904. This article and Professor Schuchert's memoir in the American Journal of Science for the same month have been freely laid under contribution for the purposes of the present memoir.

"To Beecher we owe the first natural classification of the Brachiopoda and Trilobita based on the law of recapitulation and on chronogenesis. He also gave a very philosophic account as to the origin and significance of spines in plants and animals. On these works his reputation in days to come will chiefly rest."*

In 1893 there was discovered in the Utica formation near Rome, New York, a band, not over one-fourth of an inch thick, in which occur the trilobites *Triarthrus* and *Trinucleus*, exquisitely preserved as pseudomorphs in iron pyrite, retaining antennæ and legs and many of the more delicate parts. This discovery, by W. S. Valiant, afforded a hitherto unparalleled opportunity for the study of these animals. Two specimens of Trilobites with legs had been previously known; W. D. Mathew had announced the presence of antennæ, and Walcott by laborious serial sections had determined the number and approximate form of the legs and gills in a number of species. Now, however, a vastly better opportunity for precise observation of the details of the structure of these animals was presented. Beecher took out several tons of the shale and, aided by his remarkable manual dexterity, mechanical skill, and untiring patience, worked out the structure of antennæ, legs, and other ventral appendages with a minuteness which had previously been impossible. Since 1893 he published fifteen papers on the Trilobites, including in 1897 a classification based on these studies, in which the group was divided into three orders, founded chiefly on the development of the free cheeks. At the time of his death he was at work on an extensive monograph of Trilobite structure. He regarded these animals as forming a subclass equal in rank to the Entomostraca and Malacostraca, stating that in nearly every particular "the Trilobite is very primitive and closely agrees with the theoretical crustacean ancestor. Its affinities are with both the other subclasses, especially their lower orders, but its position is not intermediate." More than five hundred specimens of *Trinucleus* and *Triarthrus* were prepared by him, and Schuchert observes that few can appreciate the remarkable talent displayed in clearing the adhering black shale from these small specimens, and that it will be a long time before his equal in this delicate work is likely to appear.

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* Charles Schuchert, op. cit.

Beside his works on the Corals, Brachiopods, and Trilobites above referred to, he became in 1892 deeply interested in the significance of spines, accumulating material till 1898, when he published his memoir entitled "The origin and significance of spines," the longest of his papers and the one, according to Schuchert, which he regarded as his best and most philosophic work.

Fortunately for students of Paleontology, most of Beecher's more important papers were reissued in one volume in the Yale Bicentennial series, entitled "Studies in Evolution." He himself regarded the reprinting of already published papers as a kind of extravagance; but those interested in philosophical zoölogy will feel grateful for the combination of so many important contributions to it in the compass of one volume. His views on the classification of the Brachiopoda and Trilobita are incorporated in the translation by Eastman of Zittel's *Grundzüge der Palæontologie.*

In his bachelor days at New Haven, Beecher, with Pirsson, Penfield, and Wells, roomed in "The Attic," the top story of the Sheffield Scientific School, which was comfortably fitted up in true Bohemian style; and Jackson recalls as one of the pleasantest recollections of a visit to New Haven the memory of calls at "The Attic," where, after working hours, delightful intercourse, social and scientific, was held, often far into the night. After moving to New Haven, Beecher made his single journey abroad in company with the late Dr. George Baur, visiting many European museums.

September 12, 1894, Professor Beecher married Miss Mary Salome Galligan, of Warren, Pennsylvania, who, with two daughters, his mother, and one brother, survives him.

Always delicate, of medium height, dark hair and eyes, and apparently good physique, Professor Beecher had the aspect of a man whose years might be long in the land, and of late had seemed to enjoy excellent health, but he died suddenly, from an affection of the heart, February 14, 1904, with no warning to soften the blow to those who loved him. His remains lie in Grove Street Cemetery, New Haven, in the shadow of the Sheffield Scientific School.

The director of the school has said of him: "Quiet and unassuming, he never sought adulation, but when there was earnest work to be done, requiring skill, patience, and good judgment, he would labor quietly and industriously, bringing to bear upon the problem such a measure of common sense and of thoughtfulness that confidence in and respect for his conclusions were inevitable. * * * No matter how trivial the duty, it was always done at the appointed time, and thoroughly done. * * * As a friend he was loyal and trustworthy, and his memory will always be cherished by his associates in the Sheffield Scientific School."

One of his pupils has testified to the inspiration given by him to his students, and how his patience, perseverance, and ingenuity served as an incentive to his associates, who were drawn closely to him by his enthusiasm and entire lack of egotism.

There is no doubt that in the death of Professor Beecher not only has Yale sustained a serious loss and Paleontology a severe blow, but the ranks of those capable of bringing to the study of fossils keen insight and a philosophical spirit of inquiry, guided by principles whose value can hardly be exaggerated, are diminished by one whom science could ill afford to lose and to whom, humanly speaking, there should have remained many years of industrious and fruitful research.

## MEMBERSHIP IN SCIENTIFIC SOCIETIES.

Ann Arbor Scientific Association.
Albany Institute.
New York Microscopical Society.
American Association of Conchologists.
Connecticut Academy of Arts and Sciences.
Berzelius Society, New Haven, Connecticut (honorary).
Dana Natural History Society, Albany, New York (honorary).
Geological Society of Washington, D. C.
Sigma Xi, New Haven, Connecticut.
Malacological Society of London.
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# LEWIS BOSS

By Benjamen Boss
Feb. 1920

Lewis Boss

NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA

BIOGRAPHICAL MEMOIRS
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# BIOGRAPHICAL MEMOIR

OF

# LEWIS BOSS

1846-1912

BY

BENJAMIN BOSS

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1918

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# LEWIS BOSS

## 1846-1912

BY BENJAMIN BOSS

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Lewis Boss, astronomer, was born at Providence, R. I., on October 26, 1846, the son of Samuel P. and Lucinda (Joslin) Boss. He died at Albany, N. Y., on October 5, 1912. Though there is no record of scientific forebears, nor any trace of scientific tastes in his brothers and sisters, Lewis Boss evidenced a strong inclination toward a scientific career even in early youth, as was manifested by his keen power of observation and by his desire to prove for himself truths generally accepted without question by the great majority. The habit of accurate representation, so necessary to the scientific man, is attributable to his father and mother, descendants of old New England families.

After a preparatory education at boarding school he entered Dartmouth College in 1866, graduating in 1870. Though his college training was classical, he showed a marked preference for scientific subjects, and this tendency was encouraged by Prof. Charles A. Young, who, at the time, held the chair of mathematics and astronomy at Dartmouth College. Through frequent visits to the college observatory, Professor Boss became acquainted with the manipulation of astronomical instruments and with the methods employed in the reduction of observations.

It was during his leisure hours, and purely as a matter of interest, that he undertook an exhaustive survey of the college grounds. In later years Professor Boss learned that this survey had served as an ideal of attainment for the students of following classes.

At the end of his college course he accepted a clerical position in the Census Office at Washington, and later moved to the Land Office. But he had not renounced the idea of a scientific career. Whenever opportunity offered he visited the

Naval Observatory. There he borrowed a sextant and chronometer and commenced a series of observations which were carefully recorded and reduced. He also investigated the errors of his instrument with great thoroughness. The results, which were of no particular scientific value, were far-reaching.

When in 1872 the U. S. Northern Boundary Commission undertook the survey of the 49th parallel boundary line between Canada and the United States, extending from the Lake of the Woods westward to the Rocky Mountains, application was made to the Naval Observatory for the services of an astronomer to be employed as civilian astronomer on the coming expedition. As there was no one available at the observatory, the commission was advised to examine Professor Boss's work. The neatly kept record of sextant observations, as well as the excellency of the observations, secured him the appointment.

On December 30, 1871, Professor Boss had married Miss Helen M. Hutchinson, of Washington, who, though a bride, consented to the separation, for a large part of several years, necessitated by the new appointment. This spirit of a willing sacrifice of her personal feelings to promote her husband's scientific needs was characteristic of her whole married life and undoubtedly contributed in large measure to her husband's success.

The years of the boundary survey were years of great unrest among the Indians. The expeditions were heavily guarded, and thus escaped attack, though several serious situations arose when it became necessary to arrange for proper defense. Only a year after the last expedition, General Custer and his force were annihilated by the same Indians who on one occasion had threatened to attack the survey party. Many tribulations resulted from the roughness of the virgin territory over which the expedition passed.

It was Professor Boss's duty to first locate the working camps by sextant observations, and then to determine accurate latitudes with the zenith telescope. The survey parties followed, setting boundary marks with reference to the latitude stations.

Not long after the enterprise started Professor Boss, in deriving the latitudes, saw the need of revising the positions of the published declinations of standard stars. Consequently he undertook to treat the observed declinations of these stars in a manner which should free them, as nearly as possible, from all systematic corrections due to imperfections in the instruments used or to imperfect reductions, finally uniting them in a homogeneous system. The computations for the catalogue were largely accomplished at night, after a hard day in the field, under very adverse conditions. His perseverance and insatiable appetite for hard work, as evidenced in this undertaking, were most characteristic of the man. But, despite his diligence, the catalogue of standard declinations was incomplete when the boundary survey terminated in 1876.

Fortunately the work was not interrupted; for the offer of the directorship of the Dudley Observatory at Albany, N. Y., by its board of trustees, followed the closing of the survey and enabled Professor Boss to complete the work of standardizing declinations.

But the long strain to which he had subjected himself told in the end, and a general breakdown resulted. Perhaps the worst phase of this was the inability to use his eyes. Undaunted, he enlisted the services of his wife, to whom he dictated his thoughts; and thus with her aid the preparation of the introduction to the catalogue was accomplished. The manuscript was reread to him, was corrected and amended where necessary, and finally was sent to the printer.

The completed catalogue of standard declinations was published in 1878 as an appendix to the Report of the U. S. Northern Boundary Commission. Professor Newcomb in his Spherical Astronomy remarked: "The declinations were so thoroughly worked up by Boss that the continued use of the A. G. system of declinations until 1900 is to be regarded as unfortunate." The system was adopted in the American Ephemeris 1883 to 1899. Its publication gave Professor Boss immediate recognition at home and abroad.

A short rest was sufficient to restore the use of his eyes and his bodily strength, so that he was able to accept the invitation of the U. S. Government to join the total solar eclipse expedition at West Las Animas, Colorado, in 1878. The results are published in the Government Report of the Eclipse. In the report the significant curved rays in the corona, near the poles of the sun, were recognized and described.

Professor Boss accepted the directorship of the Dudley Observatory at the lowest ebb in its history. The new director was chosen in hopes that something might be done to place the institution on the astronomical map. Partly in order to arouse more popular interest in the institution, and partly to fill in during the preparation of a more extensive program, Professor Boss began cometary observations.

But an invitation to join the work of the Astronomische Gesellschaft curtailed the comet work.

In 1878, after correspondence with the Zone-Commission of the Astronomische Gesellschaft, Professor Boss undertook the observation of one of the zones into which the northern sky had been partitioned for a comprehensive scheme of position-measurements, under international co-operation. The project was to secure an accurate determination of position, in duplicate, for every star in the northern sky as bright as the ninth magnitude. Such a star is about one twenty-fifth the brightness of the faintest star visible to the unassisted eye. The sky was divided into eighteen parts, and that assumed by Professor Boss embraced the zone from one to four degrees north of the celestial equator.

When the zone project was inaugurated, there had been vain hopes that all the observations could be begun and completed at approximately the same time. Unfortunately, among the many participating observatories some were unable to complete their allotted portions of the work, so that a few zones had to be reassigned. It was one of the abandoned zones which Professor Boss agreed to observe. His late start made it all the more necessary to push the observations to completion in order to comply with the general scheme.

With customary zeal, though with little assistance, Professor Boss attacked the observations and reductions so vigorously that the observations were completed in about three years from the start; the catalogue was essentially completed in 1886, and was presented for publication in 1887, the first zone to be completed. Because of the slow process of printing, the catalogue was not ready for distribution until 1890. The observations were not only quickly completed, but proved very accurate, due to the infinite care taken that every source of error should be investigated and eliminated. Altogether there were about twenty thousand observations taken of 8,241 stars.

This was the first astronomical publication containing an extensive contribution of results to emanate from the scientific exertions of the Dudley Observatory.

The successful completion of the work was not solely due to his scientific efforts. The observatory was at a low ebb in its financial history. Consequently, in order to obtain the requisite support for the undertaking, he devised ways and means of procuring additional revenue. This was accomplished partly by raising subscriptions amounting to about $2,700, partly by furnishing time to the city of Albany, and partly by turning into the treasury of the institution his salary as Superintendent of Weights and Measures of the State of New York, a position to which he was appointed in 1883 and which he held continuously until 1906.

The cometary work which Professor Boss wove into his regular work stimulated him to compete for and win a prize presented by Mr. H. H. Warner, of Rochester, for the best essay on the physical nature of comets. It evidenced his interest in the physical development of the science. In later years he often complained that the demands of astrometry upon his time did not allow him the desired amount of leisure to become more familiar with astrophysical problems, though in a spirit of fun he was wont to chaff his astrophysical friends on the general uselessness of their pretty pictures, as he termed their observational photographs.

From September, 1882, to February, 1883, he was occupied with the duty of observing the transit of Venus, December 1882. For this purpose he had been placed in charge of the Government party sent to Santiago, Chile, to observe the transit. The weather was clear on the day of the transit, and the observations were entirely successful. More than 200 photographs of Venus in transit were obtained. Curiously enough, neither Professor Boss nor his scientific assistant, Mr. Miles Rock, were at all familiar with photography, while the two professional photographers had no experience with celestial photography.

From the very day of landing the Chilian Government extended the greatest care and courtesy to Professor Boss as a representative of the U. S. Government. His equipment was transported free of charge and his party were tendered a private car from Valparaiso to Santiago. The President of Chile placed his box at the theater at the disposal of Professor Boss, and the leading citizens of the capital vied with each other in providing hospitable entertainment. Nevertheless he felt constrained to refuse all entertainment until after the successful conclusion of his enterprise, when he gave himself over to a brilliant train of social functions. In return for the hospitality he had accepted as a representative of the U. S. Government, he gave an elaborate banquet. What was his dismay when on his return to Washington this item was stricken from his expense accounts. At length the matter was amicably adjusted by nominally continuing his services until sufficient salary had accumulated to defray the expenses of the banquet.

During the period of comparative inactivity following upon the completion of the zone catalogue, Professor Boss accepted the position of editor and manager of a daily newspaper, the Albany *Morning Express,* which had sadly run down. Under the stimulus and good business judgment of the new manager, the paper was rebuilt. His editorials were widely read and quoted, especially his editorial on the death of General Grant, which was favorably commented upon by the press of the entire country.

At about the same period he took an active part in politics. He strongly espoused the candidacy of James G. Blaine for President in the campaign of 1884, when Grover Cleveland was elected, though his personal relationship to Mr. Cleveland was most friendly. He also devoted much time and energy to the senatorial campaign of William M. Evarts. Senator Evarts attributed much of the success of his campaign to the efforts of Professor Boss.

The city of Albany celebrated the bicentennial of the city's incorporation in 1886, with much pomp and ceremony. Professor Boss was one of the original committee of twenty-five appointed by the mayor to carry out the plans of the celebration. He was chairman of the Committee on Historical Pageant and was a member of three other committees. His unremitting labor and great enthusiasm stimulated the whole organization.

The cometary observations, which were taken in a somewhat desultory manner during the prosecution of the zone work, figured notably during the ensuing years and continued to absorb a large part of the labors of the observatory until 1895. The Dudley Observatory became a recognized center for securing early information in relation to comets, to be diffused in this country and in Europe by a bureau of astronomical telegrams. For these years there was rarely a newly discovered comet for which the first orbit was not computed at the Dudley Observatory. These first orbits were usually supplemented by revised calculations made at the observatory and printed in the astronomical periodicals.

In March, 1882, a new comet was discovered by Mr. Charles S. Wells, an assistant of Professor Boss. This comet turned out to be of unusual interest. It was visible for a long time, and was the first to give unmistakable evidence of the presence of sodium in its composition, therein proving that comets are not constituted solely of a narrowly restricted number of purely gaseous elements. Professor Boss prepared a special catalogue of about 500 stars to be used in comparing the positions of this comet.

In the year 1887 and again in 1889 he visited Europe, partly to accompany his family, who remained abroad during that period, and partly to visit European observatories, where he learned much regarding the future plans of astronomers. This enabled him to avoid unnecessary duplication of results in laying out a new program of work.

It will be surprising to many of his contemporaries to learn that the ideas leading to his later efforts had assumed concrete form as early as 1887, and were an outgrowth of the zone work. When the results of measurements upon the positions of about 8,000 telescopic stars had become known, a detailed and critical comparison of these with observations made in the past showed that the faint, telescopic stars participated in the parallactic effects of the solar motion in space to a degree before unsuspected. With reference to the great mass of faint, telescopic stars a general impression has prevailed that their motions were really so small that no measurable tendencies to systematic motion could be detected through a comparison of the oldest with the latest observations of such stars. Professor Boss's investigations, 1887-9, cleared up that point. They showed that the average star of the ninth magnitude is really much nearer to us than had been generally supposed, although this conclusion was accepted with marked reluctance at the time.

As the zone work neared completion he had already begun preliminary investigations in relation to an undertaking of much more ambitious scope than any in the previous history of the observatory.

The principal feature of the work was to be a critical and independent inquiry in regard to the motions of certain of the so-called fixed stars. The investigation at the time was of fresh interest, since on account of the forbidding character of the great labor involved, very little had been done by astronomers. It was known that certain stars are endowed with motions far exceeding in velocity any which are known in the solar system, but practically nothing was known in regard to the laws of these motions; and since Argelander's time no astronomer had undertaken to gather even the existing evidence in regard to them, which is scattered in hundreds of bulky volumes issued from time to time by the leading observatories. Professor Boss thought that the evidence, which was mostly of a fragmentary nature, should be collated and supplemented by a special investigation through the most refined and searching observation of which astronomical science was capable. Using Professor Boss's words: "Growing out of this problem are numerous others relating to the structure of the universe of worlds which lie beyond the solar system. Upon these problems it is proposed to bring to bear all the light which is afforded by the combined labors of astronomers during the last hundred and fifty years, which constitutes the period of exact researches relating to the stars, and to add as much as may be found practicable with the resources of the Dudley

Observatory. A successful completion of this task as a whole is to be hoped for, but cannot, of course, be promised."

Two great obstacles presented themselves to block the way of progress: First, the considerable financial backing needed for such a large undertaking, and, secondly, the need of better observing conditions than could be secured at the observatory. Unsurmountable as these obstacles must seem to the dispassionate observer, Professor Boss attacked them with characteristic energy and confidence.

The original location of the Dudley Observatory, in close proximity to the four tracks of the New York Central Railroad, proved decidedly inconsistent with the higher uses of astronomical instruments, because of the jar and smoke to which they were subjected. In addition, the room in which the meridian circle telescope was mounted was entirely unsuited for delicate observations on account of its thick masonry walls and its proximity to the main building.

For these and many other reasons Professor Boss suddenly determined, in 1891, to attempt to negotiate provisional arrangements with the city authorities by which an exchange of property between the city of Albany and the observatory might be effected. The proposition was that the city should cede to the observatory a tract of land in the western part of the city and the sum of $15,000 in exchange for the real estate then owned by the observatory.

He approached the trustees of the institution with his proposition and earnestly recommended that efforts be made to secure the removal on the terms proposed. The arrangement, however, could not be consummated without contributions from private sources.

Fortunately, in the spring of 1892, Professor Boss, after a number of conferences with Miss Catherine W. Bruce, of New York city, received from her an offer of $25,000 to increase the permanent endowment of the Dudley Observatory, provided the proposed exchange of property with the city be effected and additional funds be subscribed by other friends of the observatory sufficient to defray the cost of re-establishing the observatory on the new site.

Contributions in excess of the required amount were collected in a surprisingly short interval. Mr. Robert C. Pruyn and Mr. Charles L. Pruyn donated a new equatorial telescope, while Messrs. Dudley, Frederic P., and John Olcott provided means for modernizing the Olcott meridian circle, and for re-establishing it upon the new site in a building of special construction admirably adapted to its purpose. Miss Catherine Bruce added $10,000 to her original donations, in view of the spontaneous reply of the citizens of Albany to meet the requirements of her previous donation.

On November 8, 1893, the observatory was formally opened for inspection, and in honor of the occasion the National Academy of Sciences and many prominent scientific and educational men were present.

Thus the Dudley Observatory, well equipped for its special work, found itself prepared in 1894 to enter upon a renewed career of astronomical activity under greatly improved conditions.

During the interval made necessary for the purpose of arranging a new campaign, the observatory again became active in the observation of comets and minor planets and in computations relating to them. The minute instrumental errors of the telescope to be used were also thoroughly investigated during this period.

Since the financial condition of the observatory did not warrant as extensive a plan of observation as had gradually been crystallizing, Professor Boss, practical to the extreme, was governed by two rules: first, that the program of work should be organized in distinct, successive steps, in such a manner that each should contribute to the problem sufficient in value to warrant the undertaking of it in and for itself; second, that he should not in advance promise to accomplish more than one of these steps. In this way he hoped to escape the charge of undertaking what some might consider manifestly too great a task for his comparatively small resources; and, on the other hand, he had the advantage of working along the lines of a systematic, connected, and cumulative program with all the incentive and inspiration resulting from a lofty aim.

As a preliminary step in this program he began observations upon stars, suspected of sensible motion, in the belt of sky between 20° and 41° south of the equator, with a view to the more accurate determination of their motions. The field chosen was one practically inaccessible to the principal observatories of Europe, owing to their more northerly latitude. While the computations in the preparation of the catalogue were for the most part finished within a few years after the last observations were taken, the catalogue of 8,276 stars has not yet been published, though it is now (in 1917) going through the press.

Another item contributed toward the contemplated whole was completed in 1898. It dealt with the positions and motions of 289 of the principal stars of the southern hemisphere, and was followed in 1903 with a catalogue giving the positions and motions of 627 principal standard stars. This catalogue was derived through a thorough and painstaking treatment of the systematic errors of catalogues, the corrections of the catalogues for these errors, and the consequent combination of the whole material in a fundamental system.

Meanwhile, the results of many years of study relating to the problems of proper-motion had led Professor Boss to the formation of a manuscript card catalogue comprising about 26,000 stars, selected either because of known or suspected proper-motion. It was his intention to secure observations of all of these stars, to form a catalogue from the observed positions, and then to compare these modern observations with those taken at intervals in the past by many other observers. From a comparison between the ancient and modern positions of a star, its precise direction of motion and the amount of that motion could be determined.

Though appropriations from the Bache Fund of the National Academy of Sciences, together with generous private contributions by the trustees of the Dudley Observatory, had financed his plans thus far, the undertaking of so stupendous a project as the observation and accurate determination of the positions and proper-motions of 26,000 stars would have been impossible had not the Carnegie Institution, in 1903, decided to lend financial aid to the undertaking.

The great demand for preliminary results for some of the brighter stars led to the preparation of a catalogue of 4,300 of the brighter stars whose positions and proper-motions were designed in the first place as a foundation for an exact determination of precession and solar motion, and in the second place as a normal of reference in relation to the stars visible to the unassisted eye. This catalogue in the end grew to include 6,188 stars. The work was, essentially, a collection and mathematical discussion of all the meridian observations of precision that had been made upon the stars visible to the naked eye during the entire history of astronomy, in order to determine the relative motions of each, as well as their positions—past, present, and future—as exactly as they could be calculated from existing measurements.

In this catalogue, entitled the "Preliminary General Catalogue of 6,188 Stars," there is epitomized for each star all that is known of its history as a moving body. It is therefore designed to be and has proved to be a useful work of reference. The catalogue was not completed and printed until 1910.

Even with the aid furnished by the Carnegie Institution of Washington, dating from 1903, and a donation of $25,000 to the Dudley Observatory by Mr. Frederic P. Olcott, the main project seemed too large to accomplish.

It was therefore an immense relief to Professor Boss to receive news in 1906 of the establishment by the Carnegie Institution of Washington of a Department of Meridian Astrometry, whose sole aim was the prosecution of his work under his direction.

In preparation for the observational program the Olcott Meridian Circle was renovated, chiefly through the substitution of newly graduated circles, and the errors of division of the regraduated circles were thoroughly investigated, as were all other instrumental corrections.

In 1907 the observations of the big list of 26,000 stars were begun, and for two years this work was continued at Albany.

As the completion of the plan necessitated the observation of those stars in the southern hemisphere not accessible from Albany, an expedition was launched on August 20, 1908, to establish an observatory in the southern hemisphere. The new branch observatory was located at San Luis, Argentina, about 500 miles west of Buenos Aires, on the lower plateau of the Andes. The expedition was equipped with the same instruments used at Albany and was manned principally by the same staff employed at Albany. Professor R. H. Tucker, of the Lick Observatory, was placed in charge of the station. The expedition was so well planned that within two days after the arrival in San Luis building operations were under way.

Messrs. Tucker and Varnum were left in San Luis to carry on the building operations, and Professor Boss sailed from Buenos Aires October 10, 1908, on the return trip. He was shipwrecked on a dark night at the southern end of San Sebastião Island. The consequent wetting, exposure, and want of food for two days left him apparently unaffected.

With his usual thoroughness he made necessary instrumental investigations before dismounting the equipment at Albany prior to shipment to San Luis. Undaunted by the shipwreck experienced on the recent homeward voyage, he sailed with the second section of the expedition on January 20, 1909, and remained at San Luis until the instruments were in working order and their errors once more determined as a test of their escape from injury. Satisfied that no sensible harm had befallen the equipment during transportation, he sailed for Europe to attend the meetings of the Astrographic Chart Congress at Paris in 1909.

The staff at the branch observatory at San Luis commenced observing in March, 1909, at the unprecedented rate of about 60,000 observations per year. Upon the completion of the work, in January, 1911, the instruments were promptly dismounted, carefully packed, and shipped to Albany, where they arrived in April, 1911. Subsequent investigation proved that the equipment had once more escaped injury in transportation. It was again set up in Albany and employed upon observation of the stars accessible from that latitude.

Meanwhile, Professor Boss had attended the Astrographic Congress at Paris, and with part of his family had made an extensive tour of Europe, visiting the principal observatories. Upon his return to Albany and in connection with consultations with other members of the committee on proposed fundamental observations desired by the Paris Congress of April, 1909, he prepared a "List of 1,059 Standard Stars for 1910."

The purpose of the catalogue was to furnish a list of standard stars homogeneous in character, whose places and proper-motions could be materially strengthened by further observation.

The Preliminary General Catalogue already referred to was published in 1910. It was expected that its chief value would be found in throwing a clearer light upon the structure and operations of the universe of stars, including the motion of the sun in space. Partly before its appearance and partly after that time, a thorough study was made of the solar motion and those problems related to such a discussion. These investigations were published in a series of papers in the *Astronomical Journal.* The last part of the series deals with the systematic motions of the stars arranged according to spectral types, and as our present ideas would seem to indicate that change of spectral type takes place as a result of a change in the age of the stars, a treatment of the motions of stars arranged according to type corresponds to a treatment of their motions with reference to the age of the stars. This investigation yielded many interesting results.

It confirmed the investigations of Prof. W. W. Campbell derived from the radial velocities of the stars, that with the progression of spectral types the star's motion is apparently accelerated, very rapidly at first, and then gradually, until in the later types the average speed of the stars is practically uniform.

It was demonstrated that the actual linear velocity of the class of stars designated A rapidly increases with the distance of the star from the Milky Way.

The paper in general was a remarkable treatise on some of the peculiarities in the structure of the sidereal universe and an admirable justification of the stand taken by Professor Boss that studies based upon the old astronomy were destined to throw as much light upon the problems of the sidereal structure as those based upon the new astronomy. It was also a justification of the task he had been foresighted enough to undertake.

A further paper dealing with the direction and relative distribution of stellar velocities has not been published. It indicates that while the distribution of the velocities in direction seems to be virtually at random, the linear velocities in the general direction of the constellation Orion bear to the linear velocities at right angles to this direction the ratio of 7 to 4.

Professor Boss contributed many small articles in addition to his larger publications. While ordinarily his work was of the non-spectacular type, his discovery of a large stream of stars in the constellation Taurus excited universal attention. The members of this group were found to be moving through space at a uniform velocity in practically parallel paths.

Late in the year 1909 the editor of the *Astronomical Journal*, Dr. S. C. Chandler, a warm personal friend of Professor Boss, transferred the editorship of the paper to him. The *Astronomical Journal* was founded by Dr. B. A. Gould in 1856, to serve as a scientific organ of astronomy in the United States. Professor Boss manifested a keen interest in the publication, not only because of its relation to American astrometry, but because it became a matter of pride with him to restore to its original flourishing condition a journal supported and successively edited by two intimate astronomical associates.

Professor Boss was an extremely hard and tireless worker, whether in the interest of his chosen work or when engaged upon outside projects. Every body of men with whom he was associated became aware of the force of his personality and his keenness of vision. He had a perfect fatality in putting his finger on the weak point of any proposition. On the other hand his constructive reasoning proved of immense value to his associates. These characteristics bore an important relation to his work and to his attitude toward the members of his staff; for he was never content to implicitly trust his associates with the conduct of any department of his work, but must personally supervise even the small details, though it increased his burdens many fold. Thus he held in his fingers all the loose ends and wove them into a carefully thought-out pattern.

Naturally such strict supervision was not calculated to bring out the originality of his associates, but they did acquire an insight into the problems presented and an enthusiasm for the work which materially aided its accomplishment. While intolerant of the sluggard or the failure, he was very patient with those who were struggling for a footing. He was at his best in the company of keen minds. To others he was quite unresponsive.

Commenting editorially on the death of Professor Boss, The Albany *Evening Journal* of October 5, 1912, said in part: "Though devoted to his science, he did not live aloof from his fellow-citizens, but always took a keen interest in matters affecting the welfare of the city. Being of thoroughly kindly disposition, he was beloved as well as esteemed by all who in the course of many years had come to know him. He became great as a scientist; he was good as a man. He will be sadly missed by those who enjoyed his friendship, and those who read of his doings that won him fame will regret that henceforth his name will be only a memory. To the world of science and to this community in particular his death is a loss that will be keenly felt."

Toward the end of his career the disregard of his physical self told, and gradually the exhausted system grew weaker and weaker, though the mental activity continued. About two years before his death his general condition became more serious. A series of attacks of varied nature assailed him, yet through it all he clung to the hope that he would soon recover sufficiently to complete the great undertaking which practically amounted to a life's effort.

While it was not granted to him to bring this work to completion, it is pleasant to recall that he carried it far enough to obtain a very fair idea of the benefits to be derived from it, and to foresee the trend of astronomical research for the coming century or two. He was a pioneer in the new developments.

Professor Boss received the gold medal of the Royal Astronomical Society, London, in 1905, and the Lalande prize of the Paris Academy of Sciences in 1911. He was elected a member of the National Academy of Sciences, the American Philosophical Society, the Astronomische Gesellschaft, and the American Academy of Arts and Sciences; foreign associate of the Royal Astronomical Society; corresponding member of the British Association for the Advancement of Science, the Prussian Academy, and the St. Petersburg Academy. He received the honorary degree of A. M., Dartmouth, 1877;

LL. D., Union, 1902; Sc. D., Syracuse, 1910; Sc. D., Dartmouth, 1912.

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NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA

BIOGRAPHICAL MEMOIRS
VOLUME XII - FOURTH MEMOIR

# BIOGRAPHICAL MEMOIR

OF

# WILLIAM HENRY BREWER
## 1828-1910

BY

RUSSELL H. CHITTENDEN

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1927

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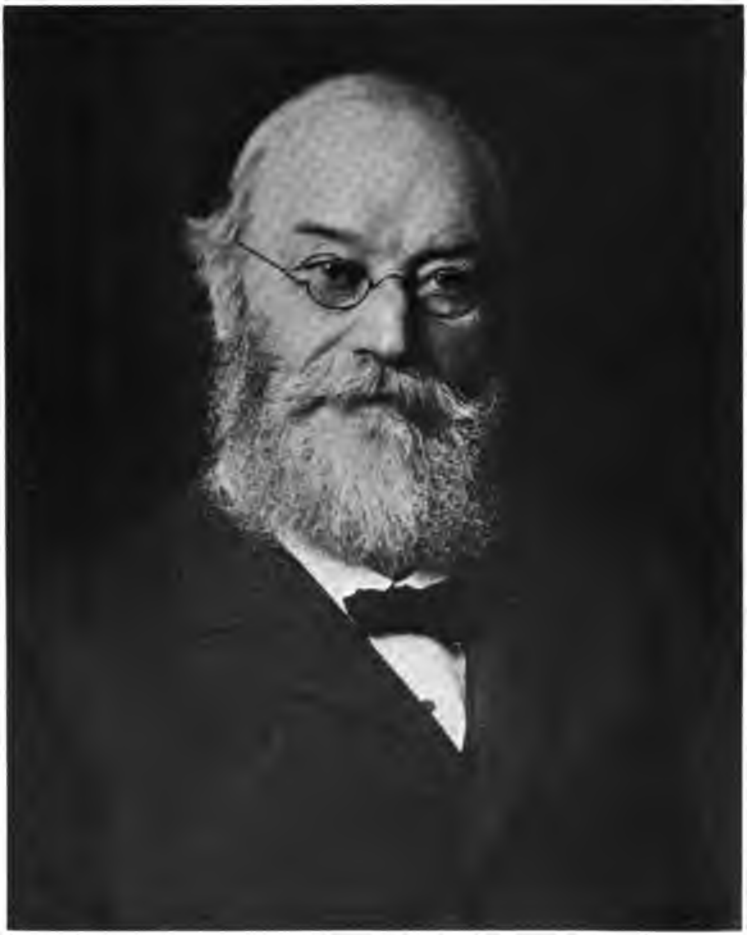

Wm H Brewer

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Professor William H. Brewer was a conspicuous figure in American science, a man of broad sympathies, wide interests, public-spirited to a high degree, and, above all, a scholar and a man of research. Living in a period when science was less specialized than at present, he was drawn into many fields of endeavor, on all of which he left the impress of his strong personality and his breadth of knowledge. Filled with a love and reverence for natural science in all its branches, he was not content to limit himself to any one special field of work, but passed from one to another with a freedom and purpose that bespoke profound knowledge and a deep-seated desire to bring to the aid of the public the benefits to be derived from the applications of science. He was a typical representative of the old school of American educators, a type we shall probably never see again. For thirty-nine years he held the chair of Agriculture in the Sheffield Scientific School at Yale, but that title by no means represents the scope of his activities; still agriculture and the sciences which contribute to its development constituted the nucleus around which his thoughts and endeavors revolved.

Brewer's ancestry was chiefly Dutch and French Huguenot, and in minor degrees Danish, French, and Scotch-Irish. His father was a descendant of Adam Brouwer Berkhoven, who emigrated from Cologne in 1642 and settled in New Amsterdam (New York). The name Berkhoven may have been his surname, but more probably indicated that he came from Bercham in North Brabant in the Netherlands, for he was of Dutch and not German origin. This name, however, persisted as late as 1700, after which the name Brouwer was used, soon changed however to Brower. The oldest tide mill on Long Island, at Gowannis Creek, in Brooklyn, owned by some member of the family, was long known as Brower's Mill.

Shortly after the close of the Revolution, there was much patriotic changing of names and William Brewer's grandfather, Nazareth Brower, who lived near Poughkeepsie, changed his name to Brewer. Of the fifteen children of Nazareth only two, however, followed the example of their father and adopted the new name. Henry, William Brewer's father, born in 1804, took the new form, Brewer, and retained it throughout his life.

William Brewer's mother was Rebecca Du Bois, born in Poughkeepsie in 1800, and married to Henry Brewer in 1827. She was a descendant of Louis Du Bois, who was born in 1626 at Wicres, in La Bassée near Lille, in French Flanders, now the old province of Artois. He was a Huguenot and on account of religious persecution went to Mannheim, Germany, where he married in 1655 Catharine Blanchen, also a Huguenot refugee. With their two children they came to America in the summer of 1660, settling in the Huguenot colony in Ulster County, New York, first at what is now Kingston, moving in 1662 to New Village, or Hurley. The following year this village was destroyed by the Indians, and the wife of Louis and her three children were carried off and held captive for three months, when they were rescued by Dutch troops sent from New York. In 1666 Louis Du Bois with some other settlers purchased from the Indians land on the Wallkill River and established the town of New Paltz, where he died in 1695.

William Henry Brewer was born on September 14, 1828, at Poughkeepsie, New York. Shortly after, his father bought a farm at Enfield, six miles from the village of Ithaca and settled the family there in the spring of 1830. On this farm young Brewer spent his childhood, going to the district school in the earlier years and later to the nearby Ithaca Academy, which he attended for four consecutive winters until the spring of 1848. During the summer months he worked on the farm with his father, acquiring a live interest in all that pertained to agriculture. Evidently the father was a progressive man, keenly appreciative of the advantages to the farmer of a knowledge of the sciences relating to agriculture. Consequently he listened sympathetically to the expressed wish of William, now twenty years of age, that he be allowed to go to New Haven and enter the "School of Applied Chemistry," under Professors John Pitkin Norton and Benjamin Silliman, Jr. Permission being granted, he started for New Haven in the fall of 1848, taking his first journey in a public conveyance.

The "School of Applied Chemistry" started at Yale in 1847, the beginning of the Sheffield Scientific School, was dominated largely by John Pitkin Norton, who from his training abroad had gained a wide knowledge of chemistry, especially in its applications to agriculture. Brewer had read accounts of some of Norton's researches, and it was this that had inspired the wish to study with the man who knew so much about scientific agriculture. Possessed of a high degree of intelligence and endowed with unbounded enthusiasm, Brewer entered on his work in the Analytical Laboratory with a determination to acquire all there was to know as speedily as possible. But after a short experience he began to realize there was much to learn; chemistry, mineralogy, geology, botany, German, French all aroused his interest, and we find from his diary that he soon understood he must take more time than the year originally planned. He records the great satisfaction his father's permission to spend two years in study in New Haven gave him. These years were full of profit, not only in the accumulation of a fund of useful knowledge and experience, but the country lad with limited vision who left the farm for the first time in 1848 was rapidily growing into a man of broad outlook, with a true appreciation of relative values, who realized that the natural sciences were destined in the near future to occupy a position of supreme importance in the development of practical agriculture and in the improvement of the industrial life of the country. Among his more intimate associates in the chemical laboratory were Samuel W. Johnson and George J. Brush, with whom he was destined later to coöperate for many years in the upbuilding of the Sheffield Scientific School.

When he returned home in the summer of 1850 Brewer was in some doubt as to his future. The promotion of agriculture through the sciences had been constantly in his mind and he had been studying with that object always before him, but the two years at Yale in close association with such men as Professors Silliman, Senior and Junior, and John P. Norton, had given him new thoughts and aspirations. Life on the farm appeared less attractive, and it is clear from his diary that he was gradually turning towards teaching as a profession. He saw that the country had need of schools or colleges of agriculture and he thought possibly here might lie his opportunity. In the meantime he worked on the farm during the summer and fall of 1850, but in December of that year he entered the Ithaca Academy as a teacher of chemistry. There he had a small laboratory and much time was spent in arranging such illustrated lectures on chemistry as his limited apparatus would permit. He was far from satisfied with his surroundings, however, and longed for an opportunity to do something more directly connected with agriculture. He was thinking constantly of a school of agriculture, and he relates in his diary of that date a long conversation with a Swiss medical student regarding the agricultural schools of Switzerland, how they were conducted, the character of the curriculum, and the success of the students after completing their studies.

Greatly to his delight, in the spring of 1851 he was invited to take charge of the Oakwood Agricultural Institute at Lancaster, in Erie County, New York. This he accepted with alacrity, thinking that here he might be able to put in operation some of the plans he had outlined in his mind for a school of agriculture, but when he took up the work at Lancaster he found conditions so impossible, students so few in number, and equipment so poor and scanty, that no satisfactory progress could be hoped for. It was a grievous disappointment, but he remained there through the year in accordance with the agreement, doing the best he could under the adverse circumstances. As he wrote in his diary, however, there was no chance to do any satisfactory work, but perhaps it was good discipline for him. At the close of the school year, in April, he returned to Ithaca, doing a little teaching, but devoting most of his time to studying botany and French in preparation for the forthcoming examinations at New Haven, when he hoped to take the bachelor's degree. Yale had decided to grant the degree of Bachelor of Philosophy to students in the "School of Applied

Chemistry" who met the specified requirements, and on Commencement Day, 1852, six men received the degree, the first class to graduate from what is now the Sheffield Scientific School. Among these six were William P. Blake, George J. Brush, and William H. Brewer.

An interesting sidelight is thrown upon the character of the examinations in Brewer's diary of that date. The examinations, he wrote, "were much more rigorous than any of us had anticipated. In chemistry, each was taken in a different manner and no one as he had expected. The examinations in this science continued about an hour each, the questions by Benjamin Silliman, Jr., in the presence of Professor John Pitkin Norton and Dr. J. Lawrence Smith. In geology the questions were by Professor Silliman, Sr. When we understood that he was to examine us in that science there was rejoicing, as none of us supposed that he would be minute, but in this we were decidedly mistaken. He was by no means as inclined to let us go with mere general principles as we had anticipated, but was minute and exact on many points where we least expected it. The botany and mineralogy were by Professor James D. Dana and were as thorough as the rest. The French was by M. Legendre."

Having obtained his degree, thus completing satisfactorily the first chapter in his career, he was uncertain what step to take next. Hampered as he was by the need to secure sufficient money for his expenses, there were necessary limitations in his choice. Above all he wished to go abroad and study with some of the renowned European chemists, but that was at the time not possible. With his ardent love of the open air and all that pertained thereto, he had found great pleasure and satisfaction in exploring the region about New Haven and that section of New York State where he had lived. He had wandered far afield in the study of flora and minerals. The mountains and the valleys were for him an inspiration and a delight, and nothing gave him greater pleasure than to seek and study the plants and minerals in hidden and difficultly accessible places, whether on the mountain top or in the deep gorges. All through his life this love of untrammeled nature showed itself, and when later on events so shaped themselves that he could travel far into the wild and even into the unknown, his cup of happiness was filled to overflowing. In the meantime he had to support himself, and he applied for the position of geologist and mineralogist on the Gunnison Expedition, an exploring expedition beyond the Rocky Mountains. Fortunately, on account of a delay of the mails, he lost the appointment and so by the merest chance was prevented from joining that party, all but four of whom were murdered by the Indians near Salt Lake.

Again he took up teaching in an academy, this time at Ovid, New York, where he gave the instruction in physiology, natural philosophy, and agricultural chemistry. This was a much more satisfactory position than he had had previously and for three years he remained there, until August, 1855, reasonably contented, but always looking forward to the time when he could go abroad and increase his knowledge of the world and of the sciences in which he was so deeply interested. His success at Ovid Academy was very marked and tended to strengthen his faith in his ability as a teacher. He also gave many courses of illustrated lectures in near-by towns on chemistry and natural philosophy, which helped to swell his income and thus brought nearer the time when his cherished hope could be realized. All his spare time, however, was spent in botanical work, collecting and studying the plants, and especially the mosses of that section of New York State. He also had some correspondence with Agassiz, and he undertook to collect for him the fishes of that region to aid Agassiz in his great work on the fishes of the United States. Finally, however, he found himself in a position to carry out his long delayed plan of going to Germany, and in September, 1855, he sailed for Hamburg, going by sailing vessel for economy's sake, saving thereby seventy or eighty dollars; a voyage of forty-one days.

For two years he was abroad, spending the first year at Heidelberg, mainly with Bunsen, while the larger portion of the second year he was at Munich working under the renowned Liebig. Chemistry naturally occupied the greater portion of his time, but geology, mineralogy, and especially botany were given some attention, particularly during the vacation periods when he made many excursions throughout Germany and Switzerland collecting and studying botanical specimens and minerals. In some of these excursions he covered much territory. Thus, in the summer of 1856, he walked six hundred miles through Switzerland, botanizing in many localities and collecting a wealth of botanical material. Again, he took a month's walking trip, geologizing in the Tyrol Mountains. He visited the great Hohenheim Agricultural School, near Stuttgart, at that time perhaps the most noted school of its kind in the world, and made a careful study of the methods of instruction employed there. Later, while in France, he spent some time at the École Imperiale d'Agriculture at Grignon, the most complete agricultural school of that country, and while in England prior to sailing for home he visited many of the more noted English farms. His stay in France was short, but he found time to go with the Botanical Society of France on an excursion of about two weeks in southern France, where he saw much that was new to him. In Paris he was able to attend the lectures of the distinguished chemist Chevreul, during his two months' stay in that city.

Thus ended the two years of European study, but the mere recital of these facts gives only a faint suggestion of all that he absorbed during this eventful period. As one reads the many letters he wrote home during these two years, it is easy to perceive that Brewer quickly caught the spirit of the great masters with whom he was studying, and that they inspired in him an enthusiasm for better means and methods of instruction and research in the sciences to which he was devoted. Under Liebig, particularly, he gained broader views of the many ways in which chemistry could aid agriculture, both directly and indirectly. He evidently looked on Bunsen as the more profound and brilliant chemist, but Liebig gave him much to think about in matters pertaining to the life processes of animals and plants, the cultivation of the soil and the broader aspects of agriculture as a science and an art.

There is no evidence in Brewer's letters of that date that he contemplated taking up chemistry as a profession. Chemistry with him was a means to an end, that end being agriculture, but he was so in love with the natural sciences that he worked at them all with almost equal zeal. Even in these earlier years he had an encyclopedic mind, and it simply was not in him to confine his intellectual activities to any one field of work. His temperament was such that he took a keen and vivid interest in everything about him, and he was rapidly accumulating a fund of information and original knowledge on many subjects, destined to be of great help to him in later life. His letters during this European experience were filled with observations of all kinds, not only on scientific matters but on social customs, habits of life of the people, political and economic problems, etc. Nothing was too insignificant to be noted and remarked upon, nothing escaped his eyes, and as a result, when Brewer returned to America, he came back equipped with an amount of special and general knowledge possessed by few men of his age.

After his return from abroad he accepted the professorship of natural sciences at Washington College, Pennsylvania, now Washington and Jefferson College, but in 1860 an opportunity presented itself which he was quick to seize. In that year the State Legislature of California authorized a geological survey of the State calling for, among other things, a full and scientific description of its botanical productions. Professor J. D. Whitney was the geologist in charge and he offered to Brewer the position of first assistant on this survey. Consequently, on October 22, 1860, Brewer sailed for California with all the baggage and instruments for the survey, by way of the Isthmus of Panama, reaching San Francisco November 15. He was astonished at the size and appearance of the city, then only about ten years old, not expecting to see such large streets and fine buildings as met his eye. On the first of December the party was at Los Angeles, then a city of about 3,500 inhabitants, and on the plain about twenty miles from the sea and fifteen miles from the mountains they made their first camp and started the work of the survey.

For four years Brewer had charge of the field parties during the summer, spending the winters in San Francisco working up his notes. This survey under Whitney was thorough and comprehensive. They climbed and named many of the higher mountains, mapped the country and reported on the geology, botany, mines, etc., of the State. While Brewer had general oversight of all the field work his special duty was the study of the flora of the State. The botanical collections were made entirely under his direction and mostly by him. The total number of species collected was about two thousand, and when it is remembered that these plants were growing spontaneously over an area of about 160,000 square miles, it is clear that Brewer must have become thoroughly acquainted with the geography of the State of California. In his Journal, under date of December 19, 1862, he wrote, "The field work for the year has closed. I have been adding up my perigrinations in this State since I arrived twenty-five months ago, and the following are the figures: mule-back, 3,981 miles; on foot, 2,067 miles; public conveyance, 3,216 miles; a total of 9,264 miles. This has been over an area 625 miles long in extreme length, and has been nearly all in the coast ranges. Probably no man living has so extensive a knowledge of the coast ranges of this State from personal observation as I have, but I have seen very little of the grand features of the Sierras." He had, however, two years more of exploring in California before his work there was finished.

These four years in the wilds of California were glorious years for Brewer. Here he had opportunity to utilize all his accumulated knowledge of geology, botany, geography, etc. Things new and unusual were all about him, exciting his curiosity and his admiration; peculiar geological formations, mineral deposits, new and rare plants, lofty mountains, beautiful valleys, wonderful forests, all combined to keep his enthusiasm for the work in hand at a high level. His Journal teems with vivid descriptions of the wonderful scenery of that new country, but his enthusiasm reaches the highest point when he is able to record the finding of some rare plant, such as the Darlingtonia, "the wonder and admiration of botanists," which he discovered near the Castle Mountains, some twenty-five miles from Mt. Shasta.

Equally enthusiastic was he over Mt. Shasta, about which little was known. Even the height of the mountain had not been definitely determined. Brewer, with Professor Whitney and two others, made the ascent in September, 1862, one of the first parties to reach the top, the highest point of land in California. In his Journal of that date is the following record: "Williamson and Fremont guessed that it (Mt. Shasta) was 17,000 feet high, and so it went into maps at that height. Last year a Mr. Moses measured it with a barometer, which was not graduated low enough, and gave it as a little less than 14,000 feet. So much was known of its height, but of its geology I am not aware that anything was known. We have not found a particle of light in any written authority. No wonder then that we had for long months looked forward to this trip, that we gazed on the mysterious peak with longing eyes from afar off, and that the excitement increased inversely as the square of the distance diminished. We were now camped at its base." He continues, "the first four miles were up a rather gentle slope, through a forest whose beauty cannot be appreciated from any description, mostly of cone-bearing trees, all of species peculiar to the Pacific slope; cedars 20 feet in circumference, spruce as large in girth and taller, sugar pines 4 to 8 feet in diameter and 200 to 250 feet in height, pitch pines nearly as large. I measured one sugar pine that lay beside the trail; it was 7 feet in diameter, the top had been consumed by fire all above where it was 8 inches in diameter, but 225 feet remained—it must have been at least 250 or 275 feet high—and I doubt not that some of the trees of this region are over 300 feet high."

That day they ascended slowly, making various observations on the way and camped for the night at an elevation of 4,100 feet, with the lofty peak of the mountain towering above them. The next morning, many hours before sunrise, they started for the top. Brewer's Journal record reads as follows: "For half a mile or more our way lies over loose blocks of lava, or dry ashy soil, then we strike a strip of snow, up which we follow. But what a path and what a grade. Hour after hour we toil on it, sometimes in the snow, sometimes on a strip of loose rock beside it. The snow is melted into rough waves, often several feet deep, by the summer's sun, but is now frozen crisp. The bright moonlight gives way to gray dawn, and this to twilight, then the sun comes up and gilds the summit ahead of us, and casts dark shadows far into the valleys beneath.

"We are following up a sort of wide ravine in which the snow lies; on either side are sharp ridges, the naked lava standing out. It appears to have been wreathed in curious forms as it flowed there, and then in later times had weathered into fantastic shapes. Walls, battlements, pinnacles, shooting up hundreds of feet. The ascent grows steeper and steeper as we ascend toward the "Red Bluffs," a sharp ridge at the altitude of almost 13,000 feet. . . . The next thousand feet is less steep but scarcely less difficult, a part of the way over hard lava, or a conglomerate made of pieces of lava cemented with a red volcanic ash, sometimes on snow which was much more difficult. It had melted, forming a surface entirely unlike anything I have ever seen in Switzerland or Tyrol."

The height of Mt. Shasta, as they determined it, was 14,400 feet, "the highest land yet measured in the United States." In his Journal, Brewer wrote, "I feel proud that I took the first accurate barometrical observations to measure the highest point over which the stars and stripes hold jurisdiction." Mt. Shasta was plainly an extinct volcano. As Brewer wrote in his Journal, "geologically, it is nearly as barren as it is botanically. A great cone of lava, little else, not—like Ætna—made up of an almost infinite number of small lava streams, but it seems to have been formed in a comparatively short period by a few gigantic eruptions. It appears to belong to a series or chain of volcanoes that probably had their greatest activity during the Tertiary period, but extended down to comparatively modern times."

Brewer naturally expected to find on the upper slopes of Shasta alpine plants, grasses, mosses, etc., but instead he found utter barrenness. To quote from his Journal, "a few shrubs and sub-alpine plants flourish just above the timber for a few hundred feet, but all above 10,000 feet is a scene of unmixed desolation, not relieved by any plant, nor did we see insect or bird above this height. This barren scene succeeds almost immediately the disappearance of the upper zone of timber, and above 10,000 feet I sought in vain either herb or shrub in the soil, or even a moss or lichen in the rocks. Yet, strange enough, we found the famous 'red snow' in quantities (probably the *Protococcus nivalis*)."

The difference between Mt. Shasta and the lofty mountains of Switzerland, for example, Brewer thought was due to the porous character of the lava composing Shasta. As he wrote in his Journal, "In Switzerland even the few hours of sun on some days, warm into life plants wherever they can obtain soil, up to highest points of naked rock. Springs gush from many points and innumerable rills course over the higher slopes. Not so here at Shasta. The water from the melting snow is immediately absorbed by the porous lava. The soil, a mixture of volcanic ashes and comminuted lava, would undoubtedly possess great fertility with water, but as it is, is dry and dusty. From the summit to the base I saw but one spring, the waters of that sank in a few rods, and one small rill ran from the snows of a ravine, and that, too, sank in less than half a mile from the snow."

With all his work and tiresome travel, Brewer found time to write innumerable letters home, and a perusal of these shows perhaps more clearly than anything else his great enthusiasm for and his deep interest in the natural beauties of California. As geologist and botanist he had enthusiasm and interest in all that the State had to offer to the scienific explorer, but beyond this was a love and admiration of the wonderful scenery all about him; the light and shade on lofty mountains, the brilliant coloring of the flowers in green valleys, the songs of the birds, the magnificent trees in the forests, and the tumbling waters of the mountain streams all called forth a feeling of wonder and admiration akin to reverence, to which he was constantly giving expression.

Brewer was greatly interested in the country along the edge of the San Joaquin and Sacramento valleys, especially the tableland to the north, with its hills of lava and mountain chains. In his diary he writes, "Lassens Peak, and in fact that whole part of the chain, like Mt. Shasta, is a gigantic extinct volcano, perhaps about 12,000 feet high, a volcano not only much higher but vastly greater in every respect of magnitude and effects, than Ætna, but it is flanked by a considerable number of smaller cones, old volcanoes, from 1,000 feet high, up to that of the main peak itself, many of these cones being much higher and greater than Mt. Vesuvius.

"Here, in a former age of the world, was a scene of volcanic activity vastly surpassing anything existing now on the earth. The materials from these activities not only formed the mountains themselves, and covered the foothills, but also came down on the plain for more than 100 miles. Sometimes volcanic ashes covered the whole region many feet thick, then sheets of molten lava would flow over it, hardening into the hardest rock, then ashes and lava again. These formed beds of enormous thickness, regularly stratified, descending with a gentle slope toward the Sacramento River, and even crossing it in one place near Red Bluffs. But all volcanic action ceased ages ago, and the snows and rains falling on the high lands about Lassens Peak form streams which radiate over it, and they have worn deep canyons, channels in this lava often a thousand feet deep, but generally less. Between these are table-lands, sometimes strewn with loose boulders of lava, othertimes with a surface of nearly naked lava, with only enough soil to support here and there a few straggling shrubs and herbs during the wet parts of the year."

The big trees of California naturally interested him and he measured and recorded the circumference and height of many of the larger specimens, especially those in the celebrated Calaveras Grove. At a height of three feet from the ground, the "Pride of the Forest" had a circumference of 60 feet; "Pioneers' Cabin," 74 feet, "Mother and Son," 82 feet. He recounts how Professor Whitney counted the annual rings of one tree having a diameter of 24 feet inside the bark, cut six feet from the ground, and found its age to be 1,255 years. Many of these trees were 300 feet high, some reaching even 400 feet. Of course, this is an old story now and the "Big Trees" are known to everyone, but in 1863 it was quite different, and Brewer's interest and enthusiasm were fired by these wonderful specimens of tree growth. All through his life forestry had a great attraction for him, and there is no doubt that these big trees of California, the various groves of which he visited in due time, had a distinct influence in molding his opinions regarding forest conservation and forest management, both of which he advocated strongly later on in life.

During these years of exploration, the party was skimming the cream from the geology and geography of California, passing from one section of the State to another, climbing mountains, mapping valleys, measuring waterfalls, collecting plants and minerals. The labor was hard, but they were keyed up to a joyous endeavor that overcame all obstacles, and to Brewer, especially, no labor was too great when it brought to light some new feature in the geology of the region, some new plant, or a new mineral, or even a new experience in the picturesque or romantic. In the fall of 1863 Clarence King, who had just graduated from the Sheffield Scientific School, joined Brewer and went with him on many of the excursions made the latter part of that year. On one occasion, the last of September, Brewer and King made the ascent of Lassens Peak, about 11,000 feet in height, the description of which Brewer wrote in his Journal, "has the merit of rigid truthfulness in every particular."

"We were up at half past one, had an early breakfast by the light of the bright moon, and at 2:45 we were on our way. First, up a canyon for a thousand feet, then among rocks and over snow, crisp in the cold air, glittering in the bright moonlight. At 4, we are on the last slope, a steep ridge, now on loose boulders and sliding gravel, now on firmer footing. We avoid the snow slopes; they are too steep to climb without cutting our way by steps. We are on the south side of the peak, and the vast region in the southeast lies dim in the soft light of the moon, valleys asleep in beds of vapors, mountains dark and shadowy. At 4:30 appears the first faint line of red in the east, which gradually widens and becomes a lurid arch as we toil up the last steep slope.

"We reach the first summit and the northern scene comes into view. The snows of Mt. Shasta are still indistinct in the dusky dawn. We cross a snow field, climb up boulders and are soon on the highest pinnacles of rock. It is still, cold and intensely clear. The arch of dawn rises and spreads along the distant eastern horizon. Its rosy light gilds the cone of red cinders across the crater from where we are, Mt. Shasta comes out clear and well defined. The gray twilight bathing the dark mountains below grows warmer and lighter. The moon and stars fade, the shadowy mountains rapidly assume distinct shapes, and day comes on apace.

"As we gaze in rapture the sun comes on the scene, and as it rises, its disc flattened by the atmospheric refraction, it gilds the peaks one after another, and at this moment the field of view is wider than at any time later in the day. The Marysville Buttes rise from the vapory plain, islands in a distant ocean of smoke, while far beyond appear the dim outlines of Mt. Diablo and Mt. Hamilton, the latter 240 miles distant. North of the Bay of San Francisco, the coast ranges are clear and distinct, from Napa north to the Salmon Mountains, near the Klamath River. Mt. Helena, Mt. Johns, Yollobolly, and all the other prominent peaks are in distinct view, but rising high above all is the conical shadow of the peak we are on, projected in the air, a distinct form of cobalt blue on a ground of lighter haze—a gigantic spectral mountain, projected so high in the air that it seems far higher than the original mountain itself—but as the sun rises, it sinks into the valley, and like a ghost it fades away at the sight of the sun.

"The snow on the Salmon Mountains glitters in the morning sun, a hundred miles distant, but the great feature is the sublime form of Mt. Shasta towering above the neighboring mountains, truly a monarch of the hills. In the east, valley and mountain chain alternate until all beyond becomes indistinct in the blue distance. The peaks about Pyramid Lake are plainly seen, while Honey Lake glistens in the morning sun, seemingly quite near. A few miles to the north are four volcanic cones, the highest above 9,000 feet entirely destitute of all vegetation, scorched and broken. The lava tables beneath are covered with dark pine forests, here and there furrowed into deep canyons, or rising into mountains with pretty valleys hidden between. Several lower peaks about us are spotted with fields of snow, still clean and white, sometimes of rose color with the red microscopic plant, as in the Arctic regions. Here and there from the dark forest of pines that forms the carpet of the hills curls the smoke from some hunters' camp or Indians' fire."

These quotations show more clearly than any words of the writer could how strongly Brewer was impressed by the matchless scenery of the country which he was exploring. They also serve to show the artistic nature of the man, for like a true artist he was seemingly compelled by the very beauty of the surroundings to make a word picture in order to preserve the impression made upon his mind. When we recall the extent of his journeying through California, it is easy to understand that he must have had many occasions for expressing his enthusiastic admiration. In his field work during the year 1863 he traveled 4,243 miles, with a total for the three years of 13,507 miles, of which 6,560 miles were on horseback or mule, and 2,772 miles on foot. Truly he knew California as few other men did.

Not far from Esmeralda the party found traces of enormous glaciers there in earlier times, said to be the first found on the Pacific slope. On the lofty mountains of this region, at an altitude of about 10,000 feet, the alpine plants were especially conspicuous and Brewer reports in his Journal the collection of over one hundred species of mountain plants during his exploration of these mountains. Equally noticeable was the prevalence of *Pinus contorta,* a scrubby pine, at 8,000 to 9,000 feet, this being practically the only tree at a height of 9,700 feet. At higher levels, up to 11,000 feet or more, a low shrub, *Pinus flexilis,* was conspicuous. One of these lofty mountains was named Mt. Dana in honor of Professor James D. Dana, while another mountain, over 13,000 feet high, which Brewer did not succeed in climbing, being stopped 125 feet from the top by the glassy surface of the almost vertical rock, was named Mt. Tyndall, in honor of Professor John Tyndall, the eminent English physicist and mountain climber.

During the winter months in San Francisco, Brewer found time to participate in some of the scientific activities of this city.

He became a member of the California Academy of Sciences and for a time was its recording secretary; he lectured occasionally, taking such topics as the mountain scenery of California, and in many other ways became more or less identified with the life of the place. In 1863 he was elected Professor of Natural Science in the College of California, now the University of California, which position he accepted subject to his duties in connection with the Survey. This position, however, he did not hold long, for in the summer of 1864 he resigned to accept the Chair of Agriculture in the Sheffield Scientific School at Yale. His field work on the Survey ceased in December, 1864, after four years of fruitful endeavor and adventurous life. His experiences during this period undoubtedly had a strong influence on his later career, especially on his instruction in physical geography and in forestry, while his love for California and interest in its development lasted throughout his life. In his bibliography will be found the titles of many papers dealing with observations made during his California experiences, testifying to his continued thought of the phenomena observed there.

Before entering on his duties at New Haven, it was necessary for Brewer to complete his obligations to the Survey. The large botanical collection had to be carefully studied and the plants classified and arranged; new species described and the results put in proper shape for publication. To do all this satisfactorily, proper equipment and expert advice were needed, and these he found in the Herbarium of Harvard University where he worked from December, 1864, until April, 1865, aided by the advice of Professor Asa Gray, who described many of the new species found. Thus was prepared for the press the "Flora of California," or a systematic description of the plants growing in that State, mainly collected by Brewer, including about 2,000 species. The material thus elaborated was finally published in 1876, making a large part of Volume 1 of the Geological Survey of California, under the title "Polypetalæ," by W. H. Brewer and Sereno Watson, the latter having added somewhat to the original collections made by Brewer.

Brewer's knowledge of the western country was further broadened by a camping trip through the Rocky Mountains in the summer of 1869, with Professor J. D. Whitney and a group of four Harvard students in geology and mining, among whom was William M. Davis. In this exploring trip of three months, Brewer saw much of the geography and geology of the Rocky Mountains, also adding to his botanical collections.

In the spring of 1865 Brewer took up his work as Norton Professor of Agriculture in the Sheffield Scientific School, and for a period of thirty-eight years, until his retirement from active service in 1903, his life was devoted primarily to the interests of this vigorous department of Yale University. The chair he occupied was established as a result of the Scientific School becoming the recipient of the Land Grant Fund of Connecticut, designed by Congress (1862) to promote instruction in agriculture and the mechanic arts. In conjunction with Professors S. W. Johnson, A. E. Verrill, and Daniel C. Eaton, he organized a well-defined course in agriculture which for many years was under the special jurisdiction of Brewer and Johnson, the latter holding the Chair of Agricultural Chemistry. In the history of agriculture in Connecticut the names of Brewer and Johnson are inseparably connected. They worked together for a common good, though by methods radically different, for they were men of totally different types.

As has been well said, Brewer "was a professor of agriculture not only in the Sheffield School but throughout the State," and he labored incessantly for the advancement of agriculture in Connecticut by every means at his command. His wide knowledge and broad experience accumulated through the previous years rendered him peculiarly fitted to bring aid to the farmer. For with all his academic training he retained some of the atmosphere of the soil. He had been brought up on the farm; as a young man he had tilled the soil and gathered the crops. He knew the mind of the practical farmer and he could talk to him in ways that could be understood, and above all he carried with him an air of authority that impressed his hearers and gained their confidence. The farmers of the State soon realized that he was their friend, and that he was actuated solely by a desire to aid them, consequently he was able to accomplish much for the betterment of agriculture in Connecticut.

His influence, however, extended far beyond the confines of the State. Commencing with the first annual report of the Connecticut Board of Agriculture in 1867, his addresses to the farmers and his many papers on matters relating to agriculture were conspicuous features of the reports during a period of thirty years, adding much of value and thereby helping the circulation of the reports outside the State. The range of his contributions was large, embracing topics quite divergent, but all relating to matters in which the farmer had a live interest, such as the origin and constitution of soils; causes which affect the vitality of seeds; woods and woodlands; practical suggestions on tree-planting in sanitary effects; pollution of streams; the water supply and drainage of farm, house, and farm buildings in their sanitary relations; the educational influence of the farm; the carrying of farm products; the farm in its relation to public health; the English race horse, a lesson in the history of the art of breeding, etc.

While his colleague, Professor S. W. Johnson, was the prime mover for the creation of an agricultural experiment station in Connecticut, the first one to be established in the United States, Brewer was active in support of the movement and was a member of the Board of Control for a period of thirty-three years, serving as a member of the Executive Committee, and its secretary and treasurer from the date of its organization in 1877. Here he rendered valuable service through his knowledge, common sense, and honesty of purpose. These attributes, soon recognized at home and abroad, led to repeated calls for his services on many matters connected directly or indirectly with agriculture. Thus, as special agent on the Tenth Census, he prepared a voluminous report on the cereal production of the United States, in which he studied especially the distribution of production in accordance with geographical, physical, and climatic features; the physical and chemical character of the different cereals; the relation of cereal production to live-stock growing, etc. In the Sheffield Chemical Laboratory, under his direction, a large amount of work was done bearing on the chemical composition of the different grains and their products. He also prepared as a part of this report a brief history of American agriculture. Likewise a report on pasture and forage plants.

When in 1882 the Commissioner of Internal Revenue turned to the National Academy of Sciences for an investigation of the various products formed from starch, notably glucose, a committee of five members of the Academy was appointed to consider this question, Brewer being one of the committee. The report, which was exhaustive and based on a large amount of original work, showed conclusively that the manufacture of sugar from starch is valuable and commercially important: that the glucose is of exceptional purity and in no way inferior to cane sugar in healthfulness. Again, the National Academy was called upon by the Commissioner of Agriculture for an investigation of the sorghum sugar industry, and of the committee of four to study this question Brewer was one.

Brewer was greatly interested in the problems of animal breeding and for many years he gave a course of lectures to his students on the "Laws of Heredity and Principles of Breeding," the syllabus of these lectures having a wide circulation. The evolution of breeds of domestic animals, as illustrated in swine, was a favorite topic and was the subject of many lectures to farmers and State Boards of Agriculture. His study of the development of the American trotting horse, however, was his most important contribution to this general subject. Recognizing that the breeding registers and turf records constitute a great collection of valuable data bearing on the evolution of speed in the horse, he proceeded to arrange and study this voluminous material with a view to determining what the ultimate speed limit of the trotting horse must be. As is well recognized, the origin of most breeds is shrouded in more or less obscurity; it is uncertain how far the special traits are the result of conscious or unconscious selection, what part training, nutrition, and physical environment play in the development of the special qualities. In the case of the trotting horse, Brewer pointed out, "the formation of this new breed is so recent, the development of a special quality has been so marked, there is such an abundant literature pertaining to its history . . . that we have the data for a reasonably accurate determination of the influences at work which led to this new breed being made, the materials of which it is made, and the rate of progress of the special evolution."

The timing of horses on the race track, as far back as 1806, led to the accumulation of data bearing on the speed of trotters, and about 1818, through judicious breeding and careful training, horses were produced capable of trotting a mile in 3 minutes. By 1830 the speed had been increased to a mile in 2:32 minutes, while by 1881 it had reached a mile in 2:10¼ minutes. Brewer carefully tabulated all the available data, thereby gaining information regarding the rate of increase in speed, etc. Thus, in 1843, there was only one horse having a record of 2:30, while in 1882, 1,684 horses had a record of 2:30 or better. In 1871 there was only one horse with a record of 2:17, but in 1882 there were 18 horses having a record of 2:17 or better. Brewer obviously could not determine how far this fast gait acquired by the well-bred and trained trotter is due to inherited habit, inherited training or to adventitious variation and selection, but he got together a mass of material from which it was possible to plot curves showing how fast horses will ultimately trot and when this maximum will be reached.

In 1873, when the writer first knew Brewer, he was intensely interested in the controversies going on, especially between Bastian and Tyndall, regarding spontaneous generation. Tyndall's work on the dust of the air and the probable relation of the latter to putrefaction, infection, etc., he had followed closely and he quickly realized the full significance of these and kindred observations in their bearing on infectious diseases. He made many observations himself on micro-organisms and taught a small class of students, working under his direction on microscopic technology, the bearings of the newer knowledge on sanitation, water supply, sewage disposal, etc. It was this knowledge, and his faith in the practical value of the results gradually accumulating, that caused him to take an active part in the organization of a State Board of Health for Connecticut, and a local Board of Health for New Haven. This was a form of public service for which he was peculiarly fitted and he entered into it with all the ardor of a crusader. Opposition of all sorts had to be met and overcome, the people had to be educated, made to see that so-called obnoxious rules and regulations were for their own good. Brewer and his associates had a difficult situation to deal with, but with a combination of wisdom and good sense he guided the growth of these two boards until public health work in Connecticut came to be recognized on all sides as a safeguard to the community. He served as president of the City Board from 1876 to 1889, and as president of the State Board of Health for sixteen years, but he was on the latter board for thirty-one years, i. e., from its organization in 1877 until his retirement on account of failing health. Many-sided knowledge, combined with his pleasing personality, and especially the power to use the spoken word convincingly, yet prudently, enabled him to carry through successfully many plans for the betterment of public health. He was likewise active in the American Public Health Association.

From his earliest years Brewer had manifested great interest in forestry, an interest that had grown steadily with his increasing appreciation of the importance of the forests to the national welfare. His observations abroad, combined with his California experiences, had given him a wealth of knowledge which he was using frequently in support of proper methods of maintenance and increase of the forests of the country. In 1874 he prepared a map, based on the results of the Census of 1870, for Walker's Statistical Atlas, showing the distribution of woodland and forest systems in the United States. The following year he wrote a report which gave an analysis of the forest resources of the country. Later, when public attention was being directed to the declining condition of the forests, he became an ardent advocate for a thorough investigation of the matter, and in 1896, when at the request of the Government the subject was taken up by the National Academy of Sciences, he was one of the Commission appointed to investigate and formulate proper methods for the preservation of the forest resources of the country. As a member of this United States Forestry Commission, Brewer traveled widely over the country to the western coast and took an active part in the survey which the Commission made. Eventually, as a result of the recommendations submitted to the Government, the National Department of Forestry was established, with Mr. Gifford Pinchot as Chief Forester. When in 1900 the Yale Forest School was established, Brewer took an active part in its organization, serving as a member of its governing board and giving for several years a course of lectures on forest physiography and meteorology. He was likewise active in the organization of an undergraduate course in "Studies preparatory to the study of forestry," in the Sheffield Scientific School.

Following the request of President Roosevelt, the National Academy of Sciences appointed a committee to consider and report upon the desirability of instituting scientific explorations of the Philippine Islands and on the scope proper to such an undertaking. Of this committee Professor Brewer was appointed chairman. As a result of the study made by this committee a comprehensive report was submitted in 1903 recommending that the Government undertake the following scientific explorations: coast and geodetic work and marine hydrography; land topography, including surveys and classification of the public land; geology and mineral resources; botany; problems of forestry; zoology; anthropology. To this study Professor Brewer devoted much thought and effort, and he often expressed the wish that he might go to the islands and view with his own eyes the resources that existed there.

For many years Brewer gave to the students in the Sheffield Scientific School a course of lectures on physical geography. He naturally took great interest in this subject, his broad experience as a geographer in the survey of California, his travels elsewhere, his geographical studies in general, all combined to render him peculiarly fitted for work in this field. With his customary enthusiasm, he brought together much new and original material, built up a large collection of maps, books, and photographs, revised Warren's Physical Geography, making of it, with the new material added, one of the most authoritative textbooks on this subject, and thus created a department of study at Yale that won general recognition. As chairman of the commission appointed to organize a topographical survey of Connecticut in 1889, he gave during a period of six years freely of his time and knowledge to insure the survey being made with proper accuracy and with due regard to economy. As a result, largely of his efforts, excellent and useful maps of the State were produced. Among the many subjects in geography that especially interested him was the subject of river deposits in their bearing on delta formation. For many years he carried on experiments upon the mechanical suspension of clays in river waters and the conditions under which their sedimentation takes place, studying particularly the effect of small admixtures of mineral salts upon the rate of precipitation.

His interest in geography and geographical research often led him far afield. Twice he went on exploring voyages to the far north; once into the Greenland seas on the steamship *Miranda,* which unfortunately was wrecked near the Arctic Circle, exposing the people on board to grave dangers, from which they were rescued only after a long period of serious discomfort. The second voyage was into Behring Sea in 1899 with the Harriman Alaska Expedition, where he saw much to interest him. In the second volume of the scientific reports of this expedition is a paper by Brewer on "The Alaska Atmosphere." When the Arctic Club was founded, Brewer served for many years as its president.

To give an adequate presentation of all that Professor Brewer did for the Sheffield Scientific School at Yale during his long period of active service—from 1865 to 1903—would be a difficult matter. In the early years, when the very life of the institution was uncertain, Brewer, like his associates Brush, Gilman, Johnson and a few others, gave all his strength and energy to place the school on a firm foundation. Through his broad training he was especially qualified to fill many gaps, and this he did with unfailing generosity and with complete disregard of self-interest. Later, when he was able to limit his activities to those subjects in which he was especially interested, he became through his knowledge, enthusiasm, and patience one of the most beloved instructors in the Scientific School, looked on by his large classes of students with admiration and respect.

In the words of one of his admirers, "he was one of the most striking personalities connected with the Scientific School and with Yale University." As a member of the Governing Board of the School he helped shape its policies for that time and for the future, and as a member of the Board of Sheffield Trustees, he shared with others many of the financial and other responsibilities that pertain to such a board. His conscientious performance of all duties that devolved upon him, his excellent judgment and wise counsels made him invaluable, while his unfailing courtesy, kindliness of heart, and sweetness of disposition rendered him an associate with whom it was a pleasure to work.

His services to science and to the public were widely recognized. Washington and Jefferson College, in 1880, conferred on him the degree of doctor of philosophy. This same year he was elected a member of the National Academy of Sciences. In 1903, at the time of his retirement from active service in the university, Yale gave him the degree of doctor of laws, and the same year Wesleyan University conferred on him a similar degree. In 1909, at the time of the celebration of its fiftieth anniversary, the University of California gave him the degree of doctor of laws.

On August 14, 1858, he married Angelina Jameson, of Ovid, New York. She died in June, 1859, and ten years later, on September 1, 1868, he married Georgiana Robinson, of Exeter, New Hampshire. Of this marriage there were four children, viz., three sons and one daughter.

During the last two years of his life, failing health curtailed his activities and imposed restrictions more or less irksome, but these Brewer accepted with characteristic calmness and philosophy. On November 2, 1910, he passed quietly away, eighty-two years of age.

Brewer's traits and achievements were in a measure the result of what he had derived from John P. Norton, Bunsen, and Liebig. From them he acquired a stimulating eagerness for research which led him in many directions, into many fields. He was essentially an explorer, carefully recording his observations on every sort of scientific subject. There were no limitations in his search for truth, for with his observing temperament he could not be content in any narrow field of research, no matter how much of interest it might have for him. He was led in many directions not through lack of thoroughness, but partly because the many services demanded of him he regarded as duties, and partly because of his broad interests and his love of scientific adventure. One is reminded of the words of Sterne: "What a large volume of adventures may be grasped within this little span of life by him who interests his heart in everything and who, having eyes to see what time and chance are perpetually holding out to him as he journeyeth on his way, misses nothing he can *fairly* lay his hands on." Brewer never wittingly missed an opportunity to see and record; his powers of acquisition were exceedingly great, but he lacked the disposition, or rather the opportunity, to digest all that he had absorbed.

Again, he was so deeply possessed by a sense of personal obligation to the community that he often sacrificed himself and his time for the benefit of others in a way that few men are willing to do. As one of his colleagues wrote: "His knowledge, suggestiveness, and original ideas were at the service, and freely given, alike to his friends and to the stranger who sought him, and innumerable must be those who profited by them. How far what has been accomplished for general advancement, at many times, in many places, and by many people through his help and influence cannot be measured, but the sum total would be astonishing if we could but know it." Public service was the keynote of his life; a life of unselfish effort, in which his knowledge and experience were freely given.

Apart from his professional work and scientific achievements there is another side to Brewer's character that calls for comment, if there is to be a judgment of the whole man. His social qualities were of a rare order. He was endowed with conversational gifts of an unusual quality, and as he was possessed of a memory retentive to a remarkable degree, with a broad experience of life under many conditions, he was a delightful companion, having a fund of stories, anecdotes and merry jests that enlivened any group of which he happened to be a member. He radiated good nature, enjoyed wholesome fun, and was quick with an apt quotation or witty rejoinder when in congenial company. To those who knew him intimately his genial fellowship and friendly, generous nature constitute an abiding memory.

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NATIONAL ACADEMY OF SCIENCES
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# BIOGRAPHICAL MEMOIR

OF

# NATHANIEL LORD BRITTON

1859–1934

BY

E. D. MERRILL
*With bibliography by*
JOHN HENDLEY BARNHART

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1938

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N. L. Britton

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## 1859–1934

BY E. D. MERRILL

To establish one's self as one of the outstanding productive botanists of his time is an achievement in itself, but it is quite another thing at the same time to develop in connection with one's active scientific work, an outstanding scientific institution planned to perpetuate and increase research in the field in which the individual was interested. Yet this is the record of accomplishment of the subject of this biographical memoir. As ably expressed by Doctor Marshall A. Howe:

> "Opportunity and the man conjoined to make the career of Nathaniel Lord Britton a notable one. The City of New York, spacious and wealthy, was a fitting site for an institution to be devoted to the study of plant sciences and to the public display of plants and plant products of scientific, economic, and horticultural interest. Doctor Britton was the man of vision, energy, and resource, who, above all others, made the dream of a few a living reality. In a very large measure, it was his driving, vitalizing force that, within less than thirty-five years, converted raw materials into the New York Botanical Garden, one of the leading institutions of the kind in the world."

Born at New Dorp, Staten Island, now the Borough of Richmond of New York City, on January 15, 1859, Doctor Britton died at his home, 2965 Decatur Avenue, New York, June 25, 1934, in the seventy-sixth year of his age. He was the son of [Jasper] Alexander Hamilton Britton and Harriet Lord Turner, and it has been said that his parents hoped that he might follow a clerical career. The interest of a neighbor, John J. Crooke, an individual of considerable scientific attainments himself, led to young Britton's being sent to the School of Mines in Columbia College, where he was prepared for his future scientific career. Doubtless his early close association with the late Doctor Arthur Hollick, a classmate in the School of Mines, and the influence of Professor John Strong Newberry, Professor of Geology and Mineralogy, and an "old school" naturalist, had their effect on the shaping of Doctor Britton's future career.

It is probable that Doctor Britton was a descendant of James Britton who came to the American colonies from London in 1635, although it seems likely that the name was of French rather than of English origin. The name is not an uncommon one in the early records of New Jersey and New York. In any case William Britton settled on Staten Island about 1664. In 1695 Nathaniel Britton acquired title to the Obadiah Holmes property in New Dorp, Staten Island, and in 1925 Nathaniel Lord Britton and his wife Elizabeth Gertrude, deeded a part of this land, with the old Britton cottage, to the Staten Island Institute of Arts and Sciences to ensure its preservation as long as possible as an example of early colonial construction.

It is apparent that Doctor Britton's interest in botany developed at an early age, long before he entered college, for it is recorded that even as a child he knew the names of local plants in a way that seemed very mysterious to his parents. In any case, in spite of his collegiate training in geology and mining, the study of plants soon became his dominant interest.

In 1879, before he had reached his twenty-first birthday, he was graduated from the School of Mines of Columbia College with the degree of Engineer of Mines. At that time there was little formal instruction in botany in Columbia College, Professor Newberry giving lectures in both geology and botany. He had published numerous papers on fossil plants and a few on living ones, and naturally encouraged young Britton's botanical interests. Like many others who made their mark in botanical science in the days before the great development of laboratory technique so characteristic of modern botanical training, Dr. Britton's interest was a personal one because of his abiding interest in plants and in plant life. He was to a very considerable degree self-trained in his chosen career. He joined the Torrey Botanical Club in October, 1877, and in the year of his graduation his first extensive botanical paper appeared, this being "The flora of Richmond County, New York," in joint authorship with Arthur Hollick, although he had published shorter botanical notes in 1877 and 1878.

Following his graduation from the School of Mines he was appointed Assistant in Geology under Professor Newberry and for the five succeeding years he also served as Botanist and Assistant Geologist on the Geological Survey of New Jersey. In 1881 his "Preliminary Catalogue of the Flora of New Jersey" appeared, this apparently serving as his thesis for the degree of Doctor of Philosophy which he received that year from Columbia College. In 1887 he received an appointment as Instructor in Botany and Geology, at Columbia. He even gave courses in zoology in 1887-88. At this time he largely took over Professor Newberry's botanical instruction. In 1890 he was appointed Adjunct Professor of Botany, and in 1891 Professor of Botany. On his appointment as Director-in-Chief of the newly established but as yet unorganized New York Botanical Garden in 1896 he became Professor of Botany Emeritus at the early age of thirty-seven years. Under arrangements perfected between the Garden and Columbia University, the Director of the Garden became, ex-officio, a Professor of Botany in the University.

Doctor Britton was married on August 27, 1885 to Elizabeth Gertrude Knight who materially assisted him in his botanical efforts because of her own abiding interest in botany. Starting with a keen interest in the local flora he gradually extended his field assembling data, perhaps unconsciously at first, but later with the definite motive of preparing the famous Britton and Brown "Illustrated Flora of the Northern United States and Canada" which appeared in three volumes 1896-98; there was a second edition in 1913, and this, forty years after its first publication, is still standard although, of course, revision is now needed. It was the first fully illustrated "Flora" on any part of North America. The preparation of such a work, an enormous task in itself, did not restrict the author's output of other papers, and during much of the period devoted to its preparation Doctor Britton served as editor of the Bulletin of the Torrey Botanical Club (1889-97), the pioneer American botanical periodical.

The illustrated flora project was the joint idea of Doctor Britton and Judge Addison Brown. Its preparation was made possible through funds provided by Judge Brown, but there is every reason to believe that the initial outlay was repaid by royalties from its sale. This reference work, although of course more or less out of date, is still in demand, with steady annual sales of several hundred copies each year. While Doctor Britton devoted an enormous amount of time to its preparation, Judge Brown worked with him throughout the period of its preparation and publication.

Other outstanding major works include his "Manual of the Flora of the Northern States and Canada" (1901, ed. 2, 1905, ed. 3, 1907), "North American Trees" (1908, with J. A. Shafer), the "Flora of Bermuda" (1918), the "Bahama Flora" (1920, with C. F. Millspaugh), and "The Botany of Porto Rico and the Virgin Islands" (1923-30, with P. Wilson). His *magnum opus,* prepared in association with J. N. Rose, is "The Cactaceae", a four volume, copiously illustrated monograph of this most difficult plant family, published by the Carnegie Institution of Washington, 1919-23. In this work 124 genera and about 1,237 species of this perplexing family are described. No matter what future botanists may attempt or achieve in their consideration of this great family of plants, this Britton and Rose monograph forms a datum plane from which all future work must proceed.

Doctor Britton became interested in the flora of the West Indies at an early date, the first expedition being sent by the Garden in 1898, his own first field trip being in 1901. He participated personally in at least thirty botanical expeditions in the islands, for he was convinced that exploration of this region would be most fruitful. Most of this West Indian work was financed by him personally. In connection with the problem of financing field work he was most successful in developing cooperative expeditions whereby several institutions contributed to the expenses of field parties, the resulting collections being equitably divided among the cooperating units.

Throughout his productive life, Doctor Britton was a voluminous writer. In his earlier career, teaching duties, while of course taking time, were not allowed to restrict his productive activity, for it should be remembered that it was Britton who established and organized the Department of Botany in Columbia University. When he took charge he found very inadequate literary facilities, comprising not more than 1000 volumes. The valuable herbarium established by Doctor John Torrey, rich in types and historical material, was in the greatest disorder, suffering from neglect, and in utterly inadequate quarters. He undertook, with the greatest zeal and energy, the task of correlating the scattered elements into one series of botanical specimens and the building up of a botanical library worthy of the University. Within a few years the herbarium was more than tripled in size and the botanical library was vastly increased. Later, when charged with very heavy organization and administrative duties at the New York Botanical Garden, we find the same situation to prevail; nothing was permitted unduly to interfere with his productive output in botany. One marvels at his energy, his ceaseless mental activity, and at the diverse productive results.

In view of the comprehensive bibliography appended to this paper there is little need to go into detail regarding Doctor Britton's publishing activities. The long list speaks for itself. Others unhampered by exacting demands on their time by social duties, political contacts, appeals for funds, dealings with architects, engineers, city and corporation officials, and a thousand and one details appertaining to the establishment, financing, and development of a great institution may look with equanimity on their productive output in publication. Yet one wonders how many of them could have continued to be productive had they been faced with the multitudinal problems, large and small, that Doctor Britton met day after day, week after week, month after month, year in and year out, and still find time to produce technical paper after technical paper. It takes a rare combination of qualities, and above all persistence, abiding faith in one's work, and deep and unfaltering interest in the daily task to produce results under such circumstances, and these qualities were Doctor Britton's to an eminent degree. He worked unceasingly himself and he expected his associates to do likewise. Above all he provided the opportunities for his associates to accomplish that in which they were individually interested through his organizing and administrative ability.

After all is said and done, in spite of Doctor Britton's notable contributions to botanical science, his greatest achievement was undoubtedly the establishment and development of the New York Botanical Garden, a living monument to his memory. The institution was his in a very real sense, and to it he devoted his best efforts through much of his productive life.

Doctor Britton himself is the authority for the statement that the idea of establishing such an institution was due to a remark made by Mrs. Britton in 1888, when they were visiting the Royal Botanic Gardens at Kew, to the effect "Why couldn't we have something like this in New York?" On October 24, 1888, Mrs. Britton gave a description of Kew at a meeting of the Torrey Botanical Club, and at the next meeting of the Club a special committee was appointed, of which Doctor Britton was a member, to consider what might be done in reference to the establishment of a botanical garden in New York. On January 8, 1889, an appeal for such a garden, prepared by the committee, was adopted and ordered printed. How many potentially great projects stop here. The situation has been ably presented by Doctor H. H. Rusby.*

> "Doctor Britton's accomplishment in the establishment of our Botanical Garden is not likely to fail of appreciation by future generations, but they might easily fail to appreciate the difficulties attending such a vast work on such insufficient resources. Looking back on the conditions that confronted the enterprise, they seem appalling, and the undertaking hopeless—yet—here is the garden, just pride of a nation! None of the enthusiastic botanical band, with the exception of Judge Brown, possessed enough means to justify even the starting of a subscription list, and but a very few of them had wealthy associates who might become interested. Again it was Doctor Britton who succeeded in inducing those few to initiate a campaign for funds. For years, the attempt persisted, but the work lagged and it was not until a determined group of women, led by Mrs. Britton, took to the warpath, that the minimum endowment of $250,000 was secured, and of this only the income might be used. Money for grading, road, path and bridge building, the location of lakes and the erection of buildings and conservatories, had still to be secured from the city administration."

Following the adoption of the committee report by the Torrey Botanical Club January 8, 1889, the consent of the Department of Parks was secured providing for the establishment of the proposed garden could means for its maintenance be procured. The corporation known as "The New York Botanical Garden" was chartered by special enactment of the New York Legislature effective April 28, 1891. The list of incorporators included the names of forty-eight distinguished citizens of New York. The Act authorized and directed the Park Commissioners to set aside for the proposed garden an area not exceeding 250 acres in some park north of the Harlem River, if, within seven years, the corporation should procure by subscription an initial endowment of not less than $250,000.

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* Science n. s. 80: 108-111. 1934.

About four years later, when the required amount had been subscribed, the Park Commission was requested to set aside 250 acres in Bronx Park as a garden site, and the Board of Estimate was requested to appropriate $500,000 for the erection of suitable buildings, as had been made mandatory by the Act of the state legislature. The officers of the first Board of Managers consisted of Cornelius Vanderbilt, President; Andrew Carnegie, Vice-president; J. Pierpont Morgan, Treasurer; and N. L. Britton, Secretary.

In New York City there are several quasi-city units of great cultural value to the community. They are in part supported by direct city appropriations, in part by income from their endowments, and by gifts from philanthropically minded citizens; all are under the control of their own governing boards. Already established and in operation on this principle were the Metropolitan Museum of Art, the American Museum of Natural History, the New York Public Library, and the Brooklyn Institute of Arts and Sciences. To this category was now added the New York Botanical Garden, another orphan, adopted by and in part supported by the City; and soon after this (in 1895) the New York Zoological Park.

Late in 1895 or early in 1896 an agreement was made with Columbia College whereby the herbarium and botanical library of that institution were to be deposited at the Garden, the facilities of the Garden to be made available to the faculty and advanced students of Columbia College. On June 17, 1896, Doctor Britton was formally appointed Director-in-Chief of the new institution. The garden site, 250 acres, in Bronx Park had been set aside in July 1895, to be increased in 1915 to an area of nearly 400 acres.

The challenge that Doctor Britton met was 250 acres of raw undeveloped land, no roads, bridges, fences, or buildings, an assured endowment of $250,000 of which the income only could be used, no laboratories, library, or herbarium, no staff, but with the hope of some financial support from the city and the potential hope that citizens of means would by gift or bequest, help support the infant institution. How well he met the challenge may be briefly indicated by the statement that in the thirty-three years of his directorate he saw the Garden develop from an idea to a well developed tract of 400 acres, a commodious administrative building and museum, ample greenhouse and conservatory facilities, a great collection of books containing 43,500 bound volumes, one of the great botanical libraries of the world, a reference herbarium in excess of 1,700,000 specimens from all parts of the world, well equipped laboratories, an active and productive staff, a publishing institution sending its product to the ends of the world, its initial endowment of $250,000 increased to approximately $2,500,000, an auxiliary membership (annual, supporting, and life) of nearly 2000 individuals, and its annual city appropriation greatly increased. The end attained justified the faith of the moving spirit in the enterprise, but how many men, situated as Doctor Britton was in 1895, would have had the courage to accept the challenge, and had the faith that the desired end could be accomplished?

One marvels at the early and rapid expansion of this new institution, particularly when one considers the paucity of financial support in the early critical years. As expressed by Doctor Rusby, who also quotes the expression that in those early years every dollar of the Garden's funds was made to do the work of four: "This success, in carrying the garden through its lean early decades, could never have been accomplished but for the generous and self-denying support of as loyal a staff as has ever blessed any similar institution, and this devotion was in no small degree attributable to the director's personality." Explorations were initiated in various parts of North America, in the Philip-pines, in the West Indies, and in South America. A well-rounded research program, not confined to the taxonomy of the flowering plants and cellular cryptogams was rapidly developed, including plant physiology, plant pathology, palaeobotany, and popular education. Manuals were prepared covering the floras of the northeastern United States, the southeastern States, and the Rocky Mountain region. Soon there appeared in the periodical field the "Journal" and the "Bulletin" of the New York Botanical Garden, a series of "Contributions," and the "Memoirs," somewhat later to be followed by the establishment of "Mycologia" and "Addisonia." As early as 1901 work on the preparation of the "North American Flora" was initiated, originally planned to be completed in thirty volumes. Intended as a descriptive flora to cover all known North American species of plants in all groups from Alaska and Greenland to the West Indies and Panama, seventy-four parts were published in Doctor Britton's lifetime. This extensive undertaking was due in large part to Doctor Britton's initiative, the work being done by members of the staff of the New York Botanical Garden, with important contributions from botanists in other institutions. As another indication of his keen insight into what is necessary in a publishing botanical institution he pioneered again in creating the position of bibliographer on the staff, the first position of the kind, it is believed, in any botanical institution.

Doctor Britton's personal interests in the development of the work of the Botanical Garden were particularly strong in the building up of the very comprehensive botanical library and the great reference herbarium. He did not limit the accessions to publications and material appertaining particularly to the problems or to the areas in which he was personally interested. He took an exceedingly catholic viewpoint, in his desire to make the conditions as to material and literature of equal value to all staff members regardless of their fields of special interest. To the library he presented all published material that was personally sent to him by correspondents from all over the world, and freely used his own personal funds and secured funds from various other sources to acquire important sets of plants and private herbaria as they became available to enrich the reference collections, and books to enrich the library.

His breadth of view is illustrated by the plan originated and consummated by him of bringing together in one place the scattered herbaria and botanical literature in New York, at the Garden, including the historical Torrey herbarium and the general herbarium of Columbia University, that of Barnard College, and the herbarium of the American Museum of Natural History. His interest was not limited to the higher plants as witnessed by his fortunately consummated plans of acquiring for the Garden the very important Ellis and Everhart collection of fungi, and the magnificent Mitten collection of mosses, both collections being exceedingly rich in historical material and containing many thousands of types. In the library field he planned and consummated the purchase of all the botanical works in the library of the Conservatoire et Jardin botaniques de Genève that were duplicated when the very important DeCandolle library was presented to the latter institution, thus vastly increasing the library resources of the New York Botanical Garden.

Outside of the library and herbarium interests of Doctor Britton was the field of palaeobotany. He took advantage of the opportunity of broadening the field of the New York Botanical Garden by establishing palaeobotanical work at the Garden, fully realizing, as apparently others have not done, that palaeobotanical research can best be done in close association with a great reference herbarium. In developing this field he naturally turned to his early associate Doctor Arthur Hollick, giving him the opportunity of developing this special field of investigation at the Botanical Garden. In no other botanical institution in America, and in very few elsewhere, was the field of research so broadly planned and developed as under Doctor Britton's leadership at this, the youngest and yet one of the greatest, botanical gardens in the world.

Doctor Britton was naturally the recipient of many honors, but honors rested lightly on his shoulders. He was the recipient of the Sc.D. degree from Columbia University in 1904, and the LL.D. degree from the University of Pittsburgh in 1912. He was elected a Fellow of the American Academy of Arts and

Sciences in 1925, a member of the National Academy of Sciences in 1914, a member of the American Philosophical Society in 1928, and a foreign member of the Linnean Society of London in 1925. He served as Vice President of the American Association for the Advancement of Science in 1896, President of the Botanical Society of America in 1898 and in 1920, President of the New York Academy of Science in 1907, and was made honorary president of the International Desert Conservation League in 1930. He was chairman of the Scientific Survey of Porto Rico and the Virgin Islands from its organization, at his instigation, by the New York Academy of Sciences, until his death. In the latter part of 1934, a peak 3200 feet high in the Luquello National Park in Porto Rico was named Mount Britton in his honor, in appreciation of his many years of service in developing our biological and geological knowledge of Porto Rico.

Although slight in build and of frail physique, Doctor Britton was a man of tireless energy, quick to perceive and to execute what needed to be done, with a remarkably retentive memory, a highly developed faculty for order and dispatch, and with the gift of concise expression. He was an individual of pronounced ideas, and in the often acrid nomenclatural controversies of the last decade of the last century and the first decades of the present one, he was an outstanding champion of strict priority in publication and a strong exponent of the so-called "American" code of botanical nomenclature as contrasted to the international rules. As a result his own publications and most of those prepared by his associates in New York were issued under the "American" code. Many botanists frankly admit that certain provisions of the "American" code were superior to the original provisions of the International code. The two are now so measurably close, except on the two questions of conserved generic names and Latin diagnoses, that the acrid controversies of the productive years of Doctor Britton's botanical career are now but a memory. Differences of opinion could not be avoided between exponents of the conservative viewpoint in nomenclature and the progressive or liberal element, and Dr. Britton was a consistent liberal.

While Doctor Britton would be considered conservative in the matter of delimiting species, in generic segregation he was extreme, rather than conservative, tending to separate genera on what many botanists consider to be slight characters. Essentially, genera and species being subjective concepts, rather than objective realities, no such thing as legislative authority, as to what shall constitute the limits of a genus or a species, is possible. Doctor Britton did not dictate to his associates and subordinates, but rather let each use his own judgment on the complex problem of what constitutes the limits of this or that major or minor group. Always an individual of strong convictions, never hesitating to express his own ideas, no matter whether others might be expected to agree with him or not, Doctor Britton continued his productive work regardless of some perhaps just, but some distinctly unjust criticism. He knew what he desired to accomplish and was eminently successful in devising ways and means of accomplishing his purpose. His great accomplishment in the establishment of the New York Botanical Garden in a great and essentially commercial city, was never more than a means to an end with him, for always first and foremost in his thoughts was botanical research, the means for making such research possible, and the publication of the results obtained.

As his own financial resources increased he liberally supported, by his own personal funds, those projects that appealed to him, particularly those associated with the New York Botanical Garden. On his death, indicating his abiding faith in the institutions he helped to organize and to develop through their years of struggle, he bequeathed one-half of his estate in varying amounts, to the New York Botanical Garden, the Torrey Botanical Club, the New York Academy of Sciences, the Staten Island Institute of Arts and Sciences, and Columbia University.

Doctor Britton's wife, Elizabeth Gertrude Britton, herself a botanist of note, died four months before him, and from this shock of separation Doctor Britton never fully recovered. There were no children. He was survived by a sister, Harriet Louise Britton, and a brother, Richard H. Britton, both of Great Kills, Staten Island.

Sixty-nine species and varieties of living and fossil plants have been dedicated to Doctor Britton, and fifteen plants and one animal have been named for Mrs. Britton. In addition two species of plants have been named in honor of the two conjointly. The generic names *Brittonamra, Brittonastrum, Brittonella, Brittonrosea, Bryobrittonia,* and *Neobrittonia* perpetuate his name among botanists. Further to perpetuate his name the periodical "Brittonia" was established as an official serial of the New York Botanical Garden in 1931, devoted to those fields of botanical research in which Doctor Britton was personally interested. In 1935 the great reference herbarium of the New York Botanical Garden was officially designated as the "Britton Herbarium."

The New York Botanical Garden is a constant reminder of the energy, wisdom, scientific attainments, and organization and administrative ability of Nathaniel Lord Britton. His name is indelibly associated with the annals of botany of North and South America and the West Indies. No monument is necessary to perpetuate his name for of him, in association with the great institution he established, it may truly be said: *Si monumentum requiris, circumspice.*

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[Presidential address.] Proc. Nat. Sci. Assoc. Staten Isl. **3**: [3, 4]. November, 1891.

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An enumeration of the plants collected by Dr. Thomas Morong in Paraguay, 1888-1890. (With Thomas Morong.) Ann. N. Y. Acad. **7**: 45-96. December, 1892; 97-144. January, 1893; 145-192. February, 1893; 193-256. March, 1893; 257-280. April, 1893. Also as Contr. Herb. Columbia Coll. no. 35.

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A rearrangement of American Portulaceae. Bull. Torrey Club **20**: 135. March 15, 1893. (Review.)

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Note on a collection of Tertiary fossil plants from Potosí, Bolivia. Trans. Am. Inst. Mining Eng. **21**: 250-259, *f. 1-79.* June, 1893. Also (repaged 1-10) as Contr. Herb. Columbia Coll. no. 27.

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The use of the generic name Halesia. Gard. & For. **6**: 433, 434. October 18, 1893.

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Halesia vs. Mohria vel Mohrodendron. Gard. & For. **6**: 518. December 13, 1893.

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Cyperaceae [of northeastern North America], with the exception of Carex. Mem. Torrey Club **5**: 59-70. January 31, 1894.

Note on the herbarium of Stephen Elliott. Bull. Torrey Club **21**: 80, 81. February 20, 1894.

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Professor Greene and Jacksonia and Polanisia. Erythea **2**: 67, 68. April 1, 1894.

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Berberidaceae [of northeastern North America]. Mem. Torrey Club **5**: 162. May 5, 1894.

Menispermaceae [of northeastern North America]. Mem. Torrey Club **5**: 162, 163. May 5, 1894.

Papaveraceae [of northeastern North America]. Mem. Torrey Club **5**: 164-166. May 5, 1894.

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Sarraceniaceae [of northeastern North America]. Mem. Torrey Club **5**: 176. May 21, 1894.

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Hamamelidaceae [of northeastern North America]. Mem. Torrey Club **5**: 180, 181. May 21, 1894.

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Crataegus punctata canescens n. var. Bull. Torrey Club **21**: 231, 232. May 25, 1894.

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[Recent discovery of three species of Barbarea on Staten Island.] Proc. Nat. Sci. Assoc. Staten Isl. **4**: 32. June, 1894.

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Thomas Morong. Bull. Torrey Club **21**: 239-244. June 20, 1894.

A revision of the genus Lechea. Bull. Torrey Club **21**: 244-253. June 20, 1894. Also as Contr. Herb. Columbia Coll. no. 56.

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Aquifoliaceae [of northeastern North America]. Mem. Torrey Club **5**: 217. June 23, 1894.

Elatineaceae [of northeastern North America]. Mem. Torrey Club **5**: 225, 226. June 23, 1894.

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Violaceae [of northeastern North America]. Mem. Torrey Club **5**: 227, 228. June 23, 1894.

Onagraceae [of northeastern North America]. Mem. Torrey Club **5**: 232. June 23, 1894; 233-236. July 7, 1894.

Hydrocaryaceae [of northeastern North America]. Mem. Torrey Club **5**: 237. July 7, 1894.

Araliaceae [of northeastern North America]. Mem. Torrey Club **5**: 238. July 7, 1894.

Umbelliferae [of northeastern North America]. Mem. Torrey Club **5**: 238-245. July 7, 1894.

Ericaceae [of northeastern North America]. Mem. Torrey Club **5**: 248. July 7, 1894; 249-258. July 18, 1894.

Plumbaginaceae [of northeastern North America]. Mem. Torrey Club **5**: 255, 256. July 18, 1894.

Styraceae [of northeastern North America]. Mem. Torrey Club **5**: 256, 257. July 18, 1894.

Oleaceae [of northeastern North America]. Mem. Torrey Club **5**: 257, 258. July 18, 1894.

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Apocynaceae [of northeastern North America]. Mem. Torrey Club 5: 262, 263. July 18, 1894.

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Note on the genus Enslenia Nutt. Bull. Torrey Club 21: 314. July 20, 1894.

Convolvulaceae [of northeastern North America]. Mem. Torrey Club 5: 266-268. August 13, 1894.

Cuscutaceae [of northeastern North America]. Mem. Torrey Club 5: 268, 269. August 13, 1894.

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Labiatae [of northeastern North America]. Mem. Torrey Club 5: 277-280. August 13, 1894; 281-286. August 28, 1894.

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Scrophulariaceae [of northeastern North America]. Mem. Torrey Club 5: 289-296. August 28, 1894; 297. October 10, 1894.

Orobanchaceae [of northeastern North America]. Mem. Torrey Club 5: 298, 299. October 10, 1894.

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Pedaliaceae [of northeastern North America]. Mem. Torrey Club 5: 299. October 10, 1894.

Acanthaceae [of northeastern North America]. Mem. Torrey Club 5: 300, 301. October 10, 1894.

Rubiaceae [of northeastern North America]. Mem. Torrey Club 5: 301-304. October 10, 1894.

Caprifoliaceae [of northeastern North America]. Mem. Torrey Club 5: 304-306. October 10, 1894.

Adoxaceae [of northeastern North America]. Mem. Torrey Club 5: 307. October 10, 1894.

Valerianaceae [of northeastern North America]. Mem. Torrey Club 5: 307, 308. October 10, 1894.

Campanulaceae [of northeastern North America]. Mem. Torrey Club 5: 309, 310. October 10, 1894.

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The Columbia College Herbarium. Bull. Torrey Club **21**: 491. November 24, 1894.

An enumeration of the plants collected by Dr. Timothy E. Wilcox, U. S. A., and others in southeastern Arizona during the years 1892-1894. (With Thomas Henry Kearney.) Trans. N. Y. Acad. **14**: 21-32. December 4, 1894; 33-44. January 26, 1895. Also as Contr. Herb. Columbia Coll. no. 71.

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Flora of Nebraska. Bull. Torrey Club **21**: 534. December 24, 1894. (Review.)

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Annual report of the State Botanist of New York. Bull. Torrey Club **22**: 82. February 26, 1895. (Review.)

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Additions to and new localities for the local flora. Proc. Nat. Sci. Assoc. Staten Isl. **5**: 11. December, 1895.

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Notes on the genus Amelanchier. [Abstract.] Bot. Gaz. **22**: 234, 235. September 23, 1896. Also in Science II. **4**: 431. September 25, 1896.

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Report of the Secretary and Director-in-Chief [for 1897]. Bull. N. Y. Bot. Gard. **1**: 122-127. February 15, 1898.

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Report on the Conservatory Fund. Jour. N. Y. Bot. Gard. **1**: 184, 185. December, 1900.

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Notes on Rudbeckia hirta L. Torreya **1**: 1, 2. January 29, 1901.

A new Senecio from Pennsylvania. Torreya **1**: 21. February 23, 1901.

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Report of the Secretary and Director-in-Chief for the year 1901. Bull. N. Y. Bot. Gard. **2**: 235-267. April 25, 1902.

The collection of tree-ferns. Jour. N. Y. Bot. Gard. **3**: 109, 110, *pl. 10.* June, 1902.

An undescribed species of Hydrophyllum. Torreya **2**: 123. August 2, 1902.

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Report of the Director-in-Chief on his visit to the Royal Gardens, Kew. Jour. N. Y. Bot. Gard. **3**: 223, 224. December, 1902.

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Resident research scholarships at the New York Botanical Garden. Jour. N. Y. Bot. Gard. **4**: 25, 26. February, 1903.

An undescribed Eleocharis from Pennsylvania. Torreya **3**: 23, 24, *f. 1, 2.* February 19, 1903.

Research funds of the Scientific Alliance of New York. Science II. **17**: 314, 315. February 20, 1903.

The Bronx Park Station of the Manhattan Railway. Jour. N. Y. Bot. Gard. **4**: 41-44, *f. 1.* March, 1903.

Report of the Secretary and Director-in-Chief for the year 1902. Bull. N. Y. Bot. Gard. **2**: 409-437. March 18, 1903.

Timothy Field Allen. Bull. Torrey Club **30**: 173-177, *portr.* April 8, 1903.

A new species of Urera. Torreya **3**: 90, 91. June 12, 1903.

Report of the Director-in-Chief upon exploration in Cuba. Jour. N. Y. Bot. Gard. **4**: 95-99, *f. 12, 13.* June, 1903.

A new Lippia from Porto Rico. Torreya **3**: 105. July 25, 1903.

A new Waltheria from the Bahamas. Torreya **3**: 105, 106. July 25, 1903.

New paths at the southern end of the Garden. Jour. N. Y. Bot. Gard. **4**: 128, 129. August, 1903.

The "Newell Avenue" bridge. Jour. N. Y. Bot. Gard. **4**: 132, *f. 17.* August, 1903.

New or noteworthy North American Crassulaceae. (With Joseph Nelson Rose.) Bull. N. Y. Bot. Gard. **3**: 1-45. November 11, 1903. Issued separately in advance, September 12, 1903.

A new appropriation for construction. Jour. N. Y. Bot. Gard. **4**: 149, 150. September, 1903.

Report on Cuban exploration. Jour. N. Y. Bot. Gard. **4**: 193, 194. November, 1903.

Flora of the southeastern United States. Jour. N. Y. Bot. Gard. **4**: 215, 216. November, 1903. (Review.)

The rose mallows. Jour. N. Y. Bot. Gard. **4**: 219, 220, *pl. 17, 18.* December, 1903.

Cornelius Van Brunt. Torreya **3**: 177-179, *portr.* December 22, 1903.

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The honeysuckles. Science II. **19**: 145, 146. January 22, 1904. (Review.)

The tropical station at Cinchona, Jamaica. Jour. N. Y. Bot. Gard. **5**: 1-7, *f. 1, 2; pl. 19.* January, 1904. Reprinted (slightly abridged) in Pop. Sci. Mo. **64**: 426-430. March, 1904.

Olivia and Caroline Phelps Stokes fund for the protection of native plants. Jour. N. Y. Bot. Gard. **5**: 7, 8. January, 1904.

George Washington's palms. Jour. N. Y. Bot. Gard. **5**: 25-28, *pl. 20, 21.* February, 1904.

Botanical exploration of the Philippine Islands. Jour. N. Y. Bot. Gard. **5**: 40, 41. February, 1904.

The Juncaceae of the West Indies. Torreya **4**: 23. February 25, 1904.

Agdestis clematidea Moc. & Sessé. Torreya **4**: 24. February 25, 1904.

Crataegus Porteri Britton. Torreya **4**: 39, 40. March 12, 1904.

The birch trees of North America. [Abstract.] Torreya **4**: 46. March 12, 1904.

Four new North American birches. Bull. Torrey Club **31**: 165, 166. March 12, 1904.

Report of the Secretary and Director-in-Chief for the year 1903. Bull. N. Y. Bot. Gard. **3**: 175-206. March 22, 1904.

Viburnum molle Michx. Torreya **4**: 69. May 13, 1904.

Scirpus coloradoensis sp. nov. Torreya **4**: 93. June 8, 1904.

Explorations in Florida and the Bahamas. Jour. N. Y. Bot. Gard. **5**: 129-136, *f. 18-23.* July, 1904.

Savia bahamensis sp. nov. Torreya **4**: 104, 105. July 21, 1904.

Explorations in Florida and the Bahamas. [Abstract.] Torreya **4**: 106, 107. July 21, 1904.

An undescribed species of Alnus. Torreya **4**: 124. August 27, 1904.

A new species of Bradburya. Torreya **4**: 142. September 30, 1904.

Lenophyllum, a new genus of Crassulaceae. (With Joseph Nelson Rose.) Smithson. Misc. Coll. **47**: 159-162, *f. 18, 19; pl. 20.* October 10, 1904. Also as Smithson. Inst. Publ. no. 1479.

The Florida royal palm. Torreya **4**: 152. October 29, 1904.

Report on exploration of the Bahamas. Jour. N. Y. Bot. Gard. **5**: 201-209, *f. 36-39.* November, 1904.

Rynchospora Pringlei Greenman. Torreya **4**: 170. November 21, 1904.

On Pisonia obtusata and its allies. Bull. Torrey Club **31**: 611-615. November 26, 1904. Also as Contr. N. Y. Bot. Gard. no. 61.

Notes on the flora of the Bahamas. [Abstract.] Torreya **4**: 190, 191. December 30, 1904.

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Carex Underwoodii sp. nov. Torreya **5**: 10, 11. January 19, 1905.

Contributions to the flora of the Bahama Islands.—I. Bull. N. Y. Bot. Gard. **3**: 441-453. April 14, 1905. Issued separately in advance, February 7, 1905.

Galactia Curtissii sp. nov. Torreya **5**: 33, 34. February 28, 1905.

Jacquinia Curtissii sp. nov. Torreya **5**: 44. March 22, 1905.

Manual of the flora of the northern states and Canada. Second edition. i-xxiv, 1-1112. [April] 1905. [Second impression.] i-xxiv, 1-1122. [November] 1907.

A botanical cruise in the Bahamas. [Abstract.] Torreya **5**: 71, 72. April 27, 1905.

Report of the Secretary and Director-in-Chief for the year 1904. Bull. N. Y. Bot. Gard. **4**: 1-17. May 8, 1905.

Crassulaceae. (With Joseph Nelson Rose.) N. Am. Flora **22**: 7-74. May 22, 1905.

The North American Flora. Jour. N. Y. Bot. Gard. **6**: 77, 78. May, 1905.

Explorations in the Bahamas. Jour. N. Y. Bot. Gard. **6**: 78-85, *f. 17-21.* May, 1905.

The Olivia and Caroline Phelps Stokes fund for the protection of native plants. Jour. N. Y. Bot. Gard. **6**: 102. June, 1905.

Report on a trip to Europe. Jour. N. Y. Bot. Gard. **6**: 123-129. August, 1905.

Nomenclature at the Vienna international botanical congress. Science II. **22**: 217-219. August 18, 1905.

Contributions to the flora of the Bahama Islands.—II. Bull. N. Y. Bot. Gard. **4**: 115-127. June 25, 1906. Issued separately in advance, August 24, 1905.

The fountain in front of the Museum Building. Jour. N. Y. Bot. Gard. **6**: 140-144. September, 1905.

A lost species of Begonia apparently rediscovered. Jour. N. Y. Bot. Gard. **6**: 146-148, *f. 33.* September, 1905.

Bermuda in September. Jour. N. Y. Bot. Gard. **6**: 153-158, *pl. 29, 30.* October, 1905.

Cunoniaceae. N. Am. Flora **22**: 179, 180. December 18, 1905.

Iteaceae. N. Am. Flora **22**: 181. December 18, 1905.

Hamamelidaceae. N. Am. Flora **22**: 185-187. December 18, 1905.

### *1906*

The Cuban columneas. Torreya **5**: 215. January 10, 1906.

Further remarks on the vegetation of the Bahamas. [Abstract.] (With Charles Frederick Millspaugh.) Torreya **5**: 219, 220. January 10, 1906.

Circular relative to membership. Jour. N. Y. Bot. Gard. **7**: 1. January, 1906.

The Students Research Fund. Jour. N. Y. Bot. Gard. **7**: 1, 2. January, 1906.

Additional members of the Garden staff. Jour. N. Y. Bot. Gard. **7**: 4, 5. January, 1906.

The North American Cactaceae. [Abstract.] Torreya **6**: 12-14. January 25, 1906.

Report of the Secretary and Director-in-Chief for the year 1905. Bull. N. Y. Bot. Gard. **5**: 1-15. February 13, 1906.

Notes on West Indies Cruciferae. Torreya **6**: 29-32. February 19, 1906.

Progress of construction work during the winter. Jour. N. Y. Bot. Gard. **7**: 23, 24. February, 1906.

Contributions to the flora of the Bahama Islands.—III. Bull. N. Y. Bot. Gard. **4**: 137-143. June 25, 1906. Issued separately in advance, March 19, 1906.

The classification of Cactaceae. Jour. Hort. Soc. N. Y. **1**: 15. April, 1906. Reprinted in Pl. World **9**: 171, 172. July, 1906.

The hemlock grove on the banks of the Bronx River and what it signifies. Trans. Bronx Soc. Arts Sci. **1**: 5-13. May, 1906. Also as Contr. N. Y. Bot. Gard. no. 83.

Recent botanical explorations in Porto Rico. Jour. N. Y. Bot. Gard. **7**: 125-139, *f. 4-12*. May, 1906.

A large oak struck by lightning. Jour. N. Y. Bot. Gard. **7**: 154-156, *f. 20*. June, 1906.

First grant from the Students' Research Fund. Jour. N. Y. Bot. Gard. **7**: 157, 158. June, 1906.

Galactia Odonia Griseb. Torreya **6**: 149. July 25, 1906.

Recent explorations in Jamaica. Jour. N. Y. Bot. Gard. **7**: 245-250, *f. 43*. November, 1906.

Nature study work of the public schools. Jour. N. Y. Bot. Gard. **7**: 274, 275. December, 1906.

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Two undescribed species of Comocladia from Jamaica. Torreya **7**: 6, 7. February 7, 1907.

The sedges of Jamaica. [Abstract.] Torreya **7**: 17, 18. February 7, 1907.

A new polygalaceous tree of Porto Rico. Torreya **7**: 38, 39. February 28, 1907.

Report of the Secretary and Director-in-Chief for the year 1906. Bull. N. Y. Bot. Gard. **5**: 195-213. March 7, 1907.

[Pioneers of science in America.] John Torrey. Pop. Sci. Mo. **70**: 297, 299, *portr*. April, 1907.

Report on the continuation of the botanical exploration of the Bahama Islands. Jour. N. Y. Bot. Gard. **8**: 71-81. April, 1907.

Ribes chihuahuense sp. nov. Torreya **7**: 102. May 20, 1907.

Address delivered at the dedication to Linnaeus of the Pelham Parkway bridge over the Bronx River. Jour. N. Y. Bot. Gard. **8**: 136-138, *f. 20*. June, 1907.

Further remarks on the botanical exploration of the Bahamas. [Abstract.] Torreya **7**: 154, 155. July 19, 1907.

Erythroxylaceae. N. Am. Flora **25**: 59-66. August 24, 1907.

The sedges of Jamaica. Bull. Dep. Agr. Jamaica **5**: Suppl. 1-19. September 19, 1907. Also as Contr. N. Y. Bot. Gard. no. 97.

Further exploration in Jamaica. Jour. N. Y. Bot. Gard. **8**: 229-236. October, 1907.

Contributions to the flora of the Bahama Islands.—IV. Bull. N. Y. Bot. Gard. **5**: 311-318. February 8, 1909. Issued separately in advance, October 26, 1907.

Pereskiopsis, a new genus of Cactaceae. (With Joseph Nelson Rose.) Smithson. Misc. Coll. **50**: 331-333, *pl. 43, 44*. October 28, 1907. Also as Smithson. Inst. Publ. no. 1775.

The Boulder Bridge. Jour. N. Y. Bot. Gard. **8**: 247-250. November, 1907.

Lucien Marcus Underwood. Columbia Univ. Quart. **10**: 67-69, *portr.* December, 1907.

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Botanical exploration in Jamaica. [Abstract.] Torreya **7**: 238. January 16, 1908.

Address by the president of the Academy [at the celebration of the bicentenary of the birth of Linnaeus]. Ann. N. Y. Acad. **18**: 40, 41. January, 1908.

The herbarium of the late Dr. Otto Kuntze. Jour. N. Y. Bot. Gard. **9**: 19-21. February, 1908.

A preliminary treatment of the Opuntioideae of North America. (With Joseph Nelson Rose.) Smithson. Misc. Coll. **50**: 503-539. February 20, 1908. Also as Smithson. Inst. Publ. no. 1786.

Report of the Secretary and Director-in-Chief for the year 1907. Bull. N. Y. Bot. Gard. **6**: 1-21. February 24, 1908.

Professor Underwood's relation to the work of the New York Botanical Garden. Bull. Torrey Club **35**: 39, 40. February 29, 1908.

[Wild Jamaica cotton.] Science II. **27**: 665. April 24, 1908. Reprinted in Torreya **8**: 230, 231. September 26, 1908.

The genus Ernodea Swartz: a study of species and races. Bull. Torrey Club **35**: 203-208. April 29, 1908. Also as Contr. N. Y. Bot. Gard. no. 106.

North American trees. (With John Adolph Shafer.) i-x, 1-894, *f. 1-781*. "April" [May 9] 1908.

Botanical exploration in Jamaica. Jour. N. Y. Bot. Gard. **9**: 81-90. May, 1908.

The taxonomic aspect of the species question. Am. Nat. **42**: 225-242. May 18, 1908. Also as Contr. N. Y. Bot. Gard. no. 105.

Druce's List of British plants. (With Henry Hurd Rusby.) Torreya **8**: 113-116. May 19, 1908.

Grossulariaceae. (With Frederick Vernon Coville.) N. Am. Flora **22**: 193-225. June 12, 1908.

Connaraceae. N. Am. Flora **22**: 233-236. June 12, 1908.

The generic name Bucida. Bull. Torrey Club **35**: 303, 304, *f. 1*. July 1, 1908.

Exhibitions of specimens recently collected in Jamaica, with remarks. [Abstract.] Torreya **8**: 171. July 29, 1908.

Studies of West Indian plants—I. Bull. Torrey Club **35**: 337-345. July 30, 1908. Also as Contr. N. Y. Bot. Gard. no. 108.

Types of American grasses. Science II. **28**: 239, 240. August 21, 1908. (Review.)

Further exploration in Jamaica. Jour. N. Y. Bot. Gard. **9**: 163-172. October, 1908.

Beccari's American palms. Torreya **8**: 238-241. October 22, 1908. (Review.)

A new genus of Cactaceae. (With Joseph Nelson Rose.) Jour. N. Y. Bot. Gard. **9**: 185-188, *f. 31; pl. 48-52.* "November" [December] 1908.

Enriching soil by crimson clover. Jour. N. Y. Bot. Gard. **9**: 226-228. December, 1908.

*1909*

Studies of West Indian plants—II. Bull. Torrey Club **35**: 561-569. January 2, 1909. Also as Contr. N. Y. Bot. Gard. no. 118.

Urban's Symbolae antillanae. Torreya **8**: 293. January 6, 1909. (Review.)

Enclosing the Garden. Jour. N. Y. Bot. Gard. **10**: 1-3, *pl. 66.* January, 1909.

Darwin and botany. Pop. Sci. Mo. **74**: 355-360. "April" [March] 1909. Reprinted in Ann. N. Y. Acad. **19**: 28-33. July 31, 1909.

Report of the Secretary and Director-in-Chief for the year 1908. Bull. N. Y. Bot. Gard. **6**: 115-136. March 23, 1909.

Thompsonella, a new genus of Crassulaceae from Mexico. (With Joseph Nelson Rose.) Contr. U. S. Nat. Herb. **12**: 391, 392, *pl. 44, 45.* May 10, 1909.

Botanical exploration in the West Indies and Florida. Jour. N. Y. Bot. Gard. **10**: 99-114, *f. 17-26.* May, 1909.

The cactuses of the West Indies. [Abstract.] Torreya **9**: 126. June 1, 1909.

Scheuchzeriaceae. N. Am. Flora **17**: 41, 42. June 30, 1909.

The genus Cereus and its allies in North America. (With Joseph Nelson Rose.) Contr. U. S. Nat. Herb. **12**: 413-437, *pl. 61-76.* July 21, 1909.

Rhipsalis in the West Indies. Torreya **9**: 153-160, *f. 1-3.* August 3, 1909. Also as Contr. N. Y. Bot. Gard. no. 124.

The Botanical Garden in the Hudson-Fulton Celebration. Jour. N. Y. Bot. Gard. **10**: 171, 172. August, 1909. Reprinted (with changed title) in Torreya **9**: 189-191. September 27, 1909.

Need of additional funds. (With Charles Finney Cox and Addison Brown.) Jour. N. Y. Bot. Gard. **10**: 217-221. October, 1909.

Report on a visit to the Royal Gardens, Kew, and to the British Museum of Natural History, London, England. Jour. N. Y. Bot. Gard. **10**: 221-224. October, 1909.

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Death of Mr. Darius Ogden Mills, President of the Board of Managers. Jour. N. Y. Bot. Gard. **11**: 1. January, 1910. (Anonymous; authorship indicated in volume-index.)

The Bronx River at flood. Jour. N. Y. Bot. Gard. **11**: 2, 3. January, 1910.

Relations of botanical gardens to the public. Jour. N. Y. Bot. Gard. **11**: 25-30. "February" [March] 1910. Also in Science II. **31**: 641-644. April 29, 1910.

Report of the Secretary and Director-in-Chief for the year 1909. Bull. N. Y. Bot. Gard. **7**: 149-168. March 17, 1910.

Outlawed generic names. Jour. Bot. **48**: 110, 111. April 1, 1910.

Botanical exploration in Santa Clara, Cuba. Jour. N. Y. Bot. Gard. **11**: 109-117. May, 1910.

Recent botanical exploration in Cuba. [Abstract.] Torreya **10**: 134, 135. July 1, 1910.

Studies of West Indian Plants—III. Bull. Torrey Club **37**: 345-363. July 29, 1910. Also as Contr. N. Y. Bot. Gard. no. 135.

The Darius Ogden Mills Fund. Jour. N. Y. Bot. Gard. **11**: 225. October, 1910.

Botanical exploration in western Cuba. Jour. N. Y. Bot. Gard. **11**: 226-236, *f. 28-35*. October, 1910.

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The botany of some autumn flowers. [Abstract.] Jour. Hort. Soc. N. Y. **1**: 120, 121. January, 1911.

Parks, gardens, and playgrounds. In: Baskerville, Charles. Municipal chemistry: a series of thirty lectures by experts. 497-503, *f. 249-251*. 1911.

Rediscovery of Tillandsia Swartzii Baker. Torreya **11**: 31-33, *f. 1*. February 14, 1911.

Report of the Secretary and Director-in-Chief for the year 1910. Bull. N. Y. Bot. Gard. **7**: 271-293. March 16, 1911.

Botanical exploration in Cuba. Jour. N. Y. Bot. Gard. **12**: 89-95. May 31, 1911.

The botanical name of the wild sapodilla. Torreya **11**: 128, 129. June 19, 1911.

An undescribed Opuntia from Jamaica. Torreya **11**: 130. June 19, 1911.

Opuntia Tracyi sp. nov. Torreya **11**: 152. July 19, 1911.

John J. Crooke. Jour. N. Y. Bot. Gard. **12**: 160, 161. July, 1911.

A second species of Hernandia in Jamaica. Torreya **11**: 174. August 14, 1911.

Improvements along the western boundary of the Garden. Jour. N. Y. Bot. Gard. **12**: 174, 175. August, 1911.

Report on a visit to the Royal Gardens, Kew, England, and to the British Museum of Natural History. Jour. N. Y. Bot. Gard. **12**: 215-218. October, 1911.

*1912*

Undescribed species of Cuban cacti. (With Joseph Nelson Rose.) Torreya **12**: 13-16. January 22, 1912.

Studies of West Indian plants—IV. Bull. Torrey Club **39**: 1-14. February 10, 1912. Also as Contr. N. Y. Bot. Gard. no. 147.

The genus Hamelia Jacq. Torreya **12**: 30-32. February 15, 1912.

Charles Finney Cox. Jour. N. Y. Bot. Gard. **13**: 21-23, *portr.* February, 1912.

Report of the Secretary and Director-in-Chief for the year 1911. Bull. N. Y. Bot. Gard. **8**: 1-17. March 14, 1912.

Further botanical exploration in Cuba. Jour. N. Y. Bot. Gard. **13**: 69-76. May, 1912.

William Bayard Cutting. Jour. N. Y. Bot. Gard. **13**: 77, 78. May, 1912.

The preservation of our native plants. Craftsman **22**: 377-386. July, 1912. [Illust.]

Development of the path system of the Garden. Jour. N. Y. Bot. Gard. **13**: 124-126. August, 1912.

[The oldest tree in Manhattan. Abstract.] Torreya **12**: 275. November 10, 1912.

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Botanical exploration in Bermuda. Jour. N. Y. Bot. Gard. **13**: 189-194, *pl. 103-107.* February 4, 1913.

The Charles Finney Cox collection of Darwiniana. Jour. N. Y. Bot. Gard. **14**: 1, 2. February 13, 1913.

Report of the Secretary and Director-in-Chief for the year 1912. Bull. N. Y. Bot. Gard. **8**: 171-185. March 18, 1913.

Studies in Cactaceae.—I. (With Joseph Nelson Rose.) Contr. U. S. Nat. Herb. **16**: 239-242, *pl. 66-73.* April 10, 1913.

Cactus studies in the West Indies. Jour. N. Y. Bot. Gard. **14**: 99-109. June 3, 1913.

John Innes Kane. Jour. N. Y. Bot. Gard. **14**: 109. June 3, 1913.

Insurance of greenhouses. Jour. N. Y. Bot. Gard. **14**: 110. June 3, 1913.

The genus Epiphyllum and its allies. (With Joseph Nelson Rose.) Contr. U. S. Nat. Herb. **16**: 255-262, *pl. 78-84.* June 6, 1913.

An illustrated flora of the northern United States, Canada and the British possessions. (With Addison Brown.) Second edition. Vol. I. i-xxix, 1-680, *f. 1-1658.* Vol. II. i-iv, 1-735, *f. 1659-3329.* Vol. III. [i-iii] 1-637, *f. 3330-4666.* [June 7] 1913. Reprinted [April 7] 1936.

Addison Brown. Jour. N. Y. Bot. Gard. **14**: 119-121, *portr.* June, 1913.

John Pierpont Morgan. Jour. N. Y. Bot. Gard. **14**: 134, 135. July 26, 1913.

Four undescribed West Indian sedges. Torreya **13**: 215-217. September 2, 1913.

A destructive storm. Jour. N. Y. Bot. Gard. **14**: 160, 161. October 7, 1913.

Gardens of Bermuda. Jour. N. Y. Bot. Gard. **14**: 172-176. November 3, 1913.

Sclerocarpus africanus Jacq. in America. Torreya **13**: 273. December 30, 1913.

Rock's The indigenous trees of the Hawaiian Islands. Torreya **13**: 277, 278. December 30, 1913. (Review.)

### *1914*

Studies of West Indian plants.—V. Bull. Torrey Club **41**: 1-24. February 27, 1914. Also as Contr. N. Y. Bot. Gard. no. 164.

Circular of the Endowment Fund committee. (With William Gilman Thompson.) Jour. N. Y. Bot. Gard. **15**: 23-28. March 10, 1914.

Report of the Secretary and Director-in-Chief for the year 1913. Bull. N. Y. Bot. Gard. **8**: 253-263. April 4, 1914.

Botanical exploration in Porto Rico and islands adjacent. Jour. N. Y. Bot. Gard. **15**: 95-103, *pl. 132-134*. June 6, 1914.

Charles Budd Robinson. Jour. N. Y. Bot. Gard. **15**: 106. June 6, 1914.

George Washington Vanderbilt. Jour. N. Y. Bot. Gard. **15**: 126, 127. June 26, 1914.

Clethraceae. N. Am. Flora **29**: 3-9. August 31, 1914.

The John Innes Kane Fund. Jour. N. Y. Bot. Gard. **15**: 175, 176. October 10, 1914.

On Erigeron pusillus Nutt. Torreya **14**: 197-199. October 27, 1914.

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Report of the Secretary and Director-in-Chief for the year 1914. Bull. N. Y. Bot. Gard. **9**: 1-17. March 31, 1915.

The vegetation of Mona Island. Ann. Missouri Bot. Gard. **2**: 33-58, *pl. 1, 2.* May 17, 1915. Also as Contr. N. Y. Bot Gard. no. 175.

Grant, by the city, of the use of additional land in Bronx Park. Jour. N. Y. Bot. Gard. **16**: 85-96, *2 maps*. June 12, 1915.

Further botanical exploration of Porto Rico. Jour. N. Y. Bot. Gard **16**: 103-112. July 5, 1915.

Studies of West Indian plants.—VI. Bull. Torrey Club **42**: 365-392. July 29, 1915. Also as Contr. N. Y. Bot. Gard. no. 179.

Permanent funds and endowment. Jour. N. Y. Bot. Gard. **16**: 123-130. August 7, 1915.

Thomas Hamlin Hubbard. Jour. N. Y. Bot. Gard. **16**: 146. August 7, 1915.

History of the New York Botanical Garden. 1-16. [September 6, 1915.]

John Francis Cowell. Jour. N. Y. Bot. Gard. **16**: 191-193. September 24, 1915.

Bequest of Jacob Langeloth. Jour. N. Y. Bot. Gard. **16**: 225. November 2, 1915.

Studies of West Indian plants.—VII. Bull. Torrey Club **42**: 487-517. November 5, 1915. Also as Contr. N. Y. Bot. Gard. no. 183.

The Mansion. Jour. N. Y. Bot. Gard. **16**: 231-233, *pl. 164*. November, 1915.

A Cuban journal of natural history. Jour. N. Y. Bot. Gard. **16**: 237, 238. November, 1915.

*1916*

Report of the Secretary and Director-in-Chief for the year 1915. Bull. N. Y. Bot. Gard. **9**: 85-106. March 20, 1916.

Cassia polyphylla. Many-leaved senna. Addisonia **1**: 3, 4 *pl. 2*. March 31, 1916.

Nopalea Auberi. Auber's nopal. Addisonia **1**: 19, 20, *pl. 10*. March 31, 1916.

The natural vegetation of the Isle of Pines, Cuba. Jour. N. Y. Bot. Gard. **17**: 64-71, *pl. 170*. June 22, 1916.

Exogonium microdactylum. Slender red exogonium. Addisonia **1**: 33, 34, *pl. 17*. June 30, 1916.

Opuntia macrorhiza. Large-rooted prickly pear. Addisonia **1**: 37, 38, *pl. 19*. June 30, 1916.

Bequest of Emil C. Bondy. Jour. N. Y. Bot. Gard. **17**: 87. July 14, 1916.

Nelson Smith. Jour. N. Y. Bot. Gard. **17**: 103, 104. August 5, 1916.

The vegetation of Anegada. Mem. N. Y. Bot. Gard. **6**: 565-580. "August 31" [September 8] 1916.

The rose garden plans. Jour. N. Y. Bot. Gard. **17**: 111-115, *pl. 175-177*. September 12, 1916.

The New York Botanical Garden and Columbia University. Columbia Univ. Quart. **18**: 352-359. September, 1916.

Sisyrinchium Bermudiana. Bermuda Iris. Addisonia **1**: 43, 44, *pl. 22*. September 30, 1916.

Anthurium grandifolium. Large-leaved tail-flower. Addisonia **1**: 53, 54, *pl. 27*. September 30, 1916.

A white pine planting. Jour. N. Y. Bot. Gard. **17**: 152-154. October 14, 1916.

Studies of West Indian plants.—VIII. Bull. Torrey Club **43**: 441-469. October 20, 1916. Also as Contr. N. Y. Bot. Gard. no. 192.

A "Convention Garden." Jour. N. Y. Bot. Gard. **17**: 172, 173. November 3, 1916.

Opuntia vulgaris. Tall South American prickly pear. Addisonia **1**: 75, 76, *pl. 38*. December 30, 1916.

Echeveria australis. Southern echeveria. Addisonia **1**: 79, 80, *pl. 40*. December 30, 1916.

*1917*

Studies of West Indian plants.—IX. Bull. Torrey Club **44**: 1-37. February 12, 1917. Also as Contr. N. Y. Bot. Gard. no. 195.

Further development of the New York Botanical Garden. Jour. N. Y. Bot. Gard. **18**: 29-31. February 27, 1917.

Peperomia obtusifolia. Blunt-leaved peperomia. Addisonia **2**: 19, 20, *pl. 50.* March 31, 1917.

Report of the Secretary and Director-in-Chief for the year 1916. Bull. N. Y. Bot. Gard. **9**: 293-311. April 10, 1917.

Instruction in gardening, in cooperation with the International Children's School Farm League. Jour. N. Y. Bot. Gard. **18**: 53-61, *pl. 192.* April 13, 1917.

Courses in gardening in cooperation with the International Children's School Farm League. Jour. N. Y. Bot. Gard. **18**: 95-98. June 11, 1917.

El genero Rynchospora Vahl, en Cuba. Mem. Soc. Cubana "Felipe Poey" **2**: 185-200. "September-December, 1916" [June, 1917]. Also as Contr. N. Y. Bot. Gard. no. 194.

Forests, hygiene and ethics. N. Y. Forestry **4**$^{2}$: 24, 25, 32. July, 1917.

Selden's Everyman's garden every week. Torreya **14**: 128. July 17, 1917. (Review.)

Harrisia gracilis. Jamaica harrisia. Addisonia **2**: 41, 42, *pl. 61.* September 29, 1917.

Harrisia Martini. Martin's harrisia. Addisonia **2**: 55, 56, *pl. 68.* September 29, 1917.

Piaropus azureus. Light-blue water-hyacinth. Addisonia **2**: 67, 68, *pl. 74.* December 31, 1917.

*1918*

The relatives of catalpa trees in the West Indies. Jour. N. Y. Bot. Gard. **19**: 6-9, *pl. 209.* "January" [February] 1918.

Flora of Bermuda (illustrated). i-ix, 1-585, *frontisp., f. 1-519.* February 28, 1918.

An undescribed Scirpus from California. Torreya **18**: 36, 37, *f. 1.* March 8, 1918.

Aronia atropurpurea. Purple-fruited choke-berry. Addisonia **3**: 1, 2, *pl. 81.* March 30, 1918.

Opuntia lasiacantha. Slender white-spined prickly pear. Addisonia **3**: 19, 20, *pl. 90.* March 30, 1918.

First grant from the income of the Charles Budd Robinson Fund. Jour. N. Y. Bot. Gard. **19**: 47, 48. April 1, 1918.

Report of the Secretary and Director-in-Chief for the year 1917. Bull. N. Y. Bot. Gard. **9**: 403-433. April 30, 1918.

The Herbaceous Grounds. Jour. N. Y. Bot. Gard. **19**: 77-79. April 30, 1918.

John Adolph Shafer. Jour. N. Y. Bot. Gard. **19**: 97-99. May, 1918. Reprinted, in Spanish translation, in Mem. Soc. Cubana "Felipe Poey" **3**: 225-228. "1918" [January, 1919].

A red pine plantation. Jour. N. Y. Bot. Gard. **19**: 105, 106. May, 1918.

Spring inspection of grounds, buildings, and collections. Jour. N. Y. Bot. Gard. **19**: 106-108. May, 1918.

Torrey Botanical Club reminiscences. Mem. Torrey Club **17**: 24-28. June 10, 1918.

Aronia arbutifolia. Red-fruited choke-berry. Addisonia **3**: 33, *pl. 97*. June 29, 1918.

The flora of the American Virgin Islands. Brooklyn Bot. Gard. Mem. **1**: 19-118. July 6, 1918. Also as Contr. N. Y. Bot. Gard. no. 203.

The botany and plant products of northern South America. Science II. **48**: 156, 157. August 16, 1918. (Anonymous.) Reprinted: An investigation of the flora of northern South America. Bull. Pan. Am. Union **47**: 232-234. August, 1918. Reprinted in Jour. N. Y. Bot. Gard. **19**: 182-185. "August" [September] 1918.

The School Garden Shelter House given by Mrs. Frederick Ferris Thompson. Jour. N. Y. Bot. Gard. **19**: 179, 180, *pl. 215*. "August" [September] 1918.

James Alexander Scrymser. Jour. N. Y. Bot. Gard. **19**: 180, 181. "August" [September] 1918.

Opuntia Opuntia. Eastern prickly pear. Addisonia **3**: 49, 50, *pl. 50*. September 30, 1918.

Byron David Halsted. Jour. N. Y. Bot. Gard. **19**: 221. "September" [October] 1918.

*1919*

Dr. Henry Allen Gleason, appointed first assistant. Jour. N. Y. Bot. Gard. **20**: 39, 40. "January" [February] 1919.

Report of the Secretary and Director-in-Chief for the year 1918. Bull. N. Y. Bot. Gard. **10**: 1-24. May 12, 1919.

The Cactaceae. Descriptions and illustrations of plants of the Cactus family. (With Joseph Nelson Rose.) Volume I. i-vii, 1-236, *f. 1-302; pl. 1-36*. June 21, 1919. Carnegie Institution of Washington, Publication no. 248, volume I. Reprinted as a supplement to the Journal of the Cactus and Succulent Society of America, vols. **3-6** (1931-34).

A large tulip tree struck by lightning. Jour. N. Y. Bot. Gard. **20**: 160. August, 1919.

History of the Survey. N. Y. Acad. Sci. Survey Porto Rico **1**: 1-10. September 26, 1919.

Addisonia: its progress and publication. Jour. N. Y. Bot. Gard. **20**: 181, 182. "September" [October 7] 1919.

The Scientific Survey of Porto Rico and the Virgin Islands. Jour. N. Y. Bot. Gard. **20**: 220, 221. November, 1919.

### *1920*

Flora of the District of Columbia. Torreya **19**: 244-246. (Review.)

The wild pimento of Jamaica. Jour. N. Y. Bot. Gard. **21**: 38, 39. "February" [April 9] 1920.

About Paulownia trees. Jour. N. Y. Bot. Gard. **21**: 72, 73. "April" [May] 1920.

The Bahama flora. (With Charles Frederick Millspaugh.) i-viii, 1-695. June 26, 1920.

Cephalanthus occidentalis. Button-bush. Addisonia **5**: 17, 18, *pl. 169*. June 30, 1920.

Report of the Secretary and Director-in-Chief for the year 1919. Bull. N. Y. Bot. Gard. **10**: 213-219. June 30, 1920.

A botanical expedition to Trinidad. Jour. N. Y. Bot. Gard. **21**: 101-118. "June" [July] 1920.

The Cactaceae. Descriptions and illustrations of plants of the Cactus family. (With Joseph Nelson Rose.) Volume II. i-vii, 1-239, *f. 1-305; pl. 1-40*. September 9, 1920. Carnegie Institution of Washington, Publication no. 248, volume II. Reprinted; pages 1-148 as a supplement to the Journal of the Cactus and Succulent Society of America, vols. **6-8** (1934-36), the remainder separately in March, 1937.

Descriptions of Cuban plants new to science. Mem. Torrey Club **16**: 57-118. September 13, 1920. Also as Contr. N. Y. Bot. Gard. no. 225.

Two new West Indian plants. Torreya **20**: 83, 84. September 20, 1920.

George W. Perkins. Jour. N. Y. Bot. Gard. **21**: 179. "September" [October 13] 1920.

Report by the Director-in-Chief upon a visit to botanical institutions in England. Jour. N. Y. Bot. Gard. **21**: 197-208. November, 1920.

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Investigation of the flora of northern South America. Science II. **53**: 29, 30. January 14, 1921.

William Harris. Jour. N. Y. Bot. Gard. **22**: 13, 14. "January" [February 12] 1921.

Francis Lynde Stetson. Jour. N. Y. Bot. Gard. **22**: 44, 45. "February" [March 12] 1921.

Fanny Bridgham Fund. Jour. N. Y. Bot. Gard. **22**: 45, 46. "February" [March 12] 1921.

The leafy spurge becoming a pest. Jour. N. Y. Bot. Gard. **22**: 73-75, *f. 1*. "April" 1921

Further botanical studies in Trinidad. Jour. N. Y. Bot. Gard. **22**: 93-102. "May" 1921.

Neoabbottia, a new cactus genus from Hispaniola. (With Joseph Nelson Rose.) Smithson. Misc. Coll. **729**: 1-6, *f. 1, 2; pl. 1-4*. June 15, 1921. Also as Smithson. Inst. Publ. no. 2651.

The Cacti of Trinidad. Bull. Dep. Agr. Trin. Tobago **19**: 81-87. [June] 1921.

Stewardson Brown. Jour. N. Y. Bot. Gard. **22**: 110-112. June, 1921.

Report of the Secretary and Director-in-Chief for the year 1920. Bull. N. Y. Bot. Gard. **10**: 307-322. September 10, 1921.

[Plant nomenclature: more suggestions.] Jour. Bot. **59**: 296, 297. October, 1921.

George Valentine Nash. Jour. N. Y. Bot. Gard. **22**: 145-147, *pl. 261 (portr.)*. "August" [October] 1921.

Lathyrus latifolius. Everlasting pea. Addisonia **6**: 35, 36, *pl. 210*. October 24, 1921.

Dr. Pennell's new position. Jour. N. Y. Bot. Gard. **22**: 171, 172. "September" [December 8] 1921.

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Studies of West Indian plants.—X. Bull. Torrey Club **48**: 327-343. February 28, 1922. Also as Contr. N. Y. Bot. Gard. no. 236.

Botanical investigations in Porto Rico. Jour. N. Y. Bot. Gard. **23**: 49-59. "April" [June] 1922.

Report of the Secretary and Director-in-Chief for the year 1921. Bull. N. Y. Bot. Gard. **12**: 1-15. July 6, 1922.

Notes on the plants collected by Mr. Bucher on Pico Turquino, Cuba. (With Percy Wilson.) Jour. N. Y. Bot. Gard. **23**: 91-95. "July" [August] 1922.

Two new genera of Cactaceae. (With Joseph Nelson Rose.) Bull. Torrey Club **49**: 251, 252. August 31, 1922.

Polystachya minuta. Polystachya. Addisonia **7**: 19, *pl. 234*. September 25, 1922.

Xylophylla Epiphyllanthus. Hardhead. Addisonia **7**: 31, *pl. 240*. September 25, 1922.

The Cactaceae. Descriptions and illustrations of plants of the Cactus family. (With Joseph Nelson Rose.) Volume III. i-vii, 1-255, *f. 1-250; pl. 1-24*. October 12, 1922. Carnegie Institution of Washington, Publication no. 248, volume III.

Crotalaria retusa. Large yellow-rattlebox. Addisonia **7**: 47, *pl. 248*. December 4, 1922.

### *1923*

Studies of West Indian plants.—XI. Bull. Torrey Club **50**: 35-56. February 7, 1923. Also as Contr. N. Y. Bot. Gard. no. 238.

Three new plants of the family Rubiaceae from Trinidad. (With Paul Carpenter Standley.) Jour. Wash. Acad. **13**: 105-107. March 19, 1923.

Cyperaceae. (Text, except Carex.) In: Abrams, Le Roy. An illustrated flora of the Pacific states **1**: 255-281. 1923.

Report of the Secretary and Director-in-Chief for the year 1902. Bull. N. Y. Bot. Gard. **12**: 103-115. June 7, 1923.

Botanical exploration of Porto Rico and the Virgin Islands. Jour. N. Y. Bot. Gard. **24**: 93-99. "May" [June] 1923.

Preface [to the Botany of Porto Rico and the Virgin Islands.] N. Y. Acad. Sci. Surv. Porto Rico **5**: 1-5. August 10, 1923.

Botany of Porto Rico and the Virgin Islands. Descriptive flora.—Spermatophyta (part). (With Percy Wilson.) N. Y. Acad. Sci. Surv. Porto Rico **5**: 7-158. August 10, 1923.

An unrecorded weed in Bermuda. Torreya **23**: 67, 68. August, 1923.

Bignonia radicans. Trumpet-creeper. Addisonia **8**: 39, 40, *pl. 276*. November 10, 1923.

Phlebotaenia Cowellii. Violet-tree. Addisonia **8**: 47, 48, *pl. 280*. November 10, 1923.

The Cactaceae. Descriptions and illustrations of plants of the Cactus family. (With Joseph Nelson Rose.) Volume IV. i-vii, 1-318, *f. 1-263; pl. 1-37*. December 24, 1923. Carnegie Institution of Washington, Publication no. 248, volume IV. "Pages 1-80, text only, were distributed under date of October 9, 1923."

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Francis Alexander Schilling. Jour. N. Y. Bot. Gard. **24**: 283, 284. "December, 1923" [January, 1924].

Botany of Porto Rico and the Virgin Islands. Descriptive flora.—Spermatophyta (continued). (With Percy Wilson.) N. Y. Acad. Sci. Surv. Porto Rico **5**: 159-316. January 10, 1924.

An extraordinary December. Jour. N. Y. Bot. Gard. **25**: 15, 16. January, 1924.

Plants of the Galapagos Islands. Jour. N. Y. Bot. Gard. **25**: 10, 11. "January" [February] 1924.

Hamelia axillaris. Yellow hamelia. Addisonia **8**: 51, *pl. 282*. February 5, 1924.

Lagetta Lagetto. Lace-bark tree. Addisonia **8**: 61, *pl. 287*. February 5, 1924.

Studies of West Indian plants.—XII. Bull. Torrey Club **51**: 1-12. February 8, 1924. Also as Contr. N. Y. Bot. Gard. no. 252.

La vegetación de cayo Icacos. Revista Agr. Puerto Rico **12**: 91-96. February, 1924.

The Scientific Survey of Porto Rico and the Virgin Islands. (Estudios cientificos sobre Puerto Rico y las Islas Virgenes.) Revista Agr. Puerto Rico **12**: 109, 110. February, 1924.

Las arenas de las planicies de la costa norte de Puerto Rico. Revista Agr. Puerto Rico **12**: 157, 158. March, 1924.

Porto Rico coffee slump. Tea & Coffee Trade Jour. **46**: 653, 654. May, 1924.

Report of the Secretary and Director-in-Chief for the year 1923. Bull. N. Y. Bot. Gard. **12**: 181-193. May 28, 1924.

Descriptive flora of Porto Rico and the Virgin Islands. Jour. N. Y. Bot. Gard. **25**: 129-135. May, 1924.

Botany of Porto Rico and the Virgin Islands. Descriptive flora.—Spermatophyta (continued). (With Percy Wilson.) N. Y. Acad. Sci. Surv. Porto Rico **5**: 317-474. June 16, 1924.

A botanical expedition to extreme western Cuba. Jour. N. Y. Bot. Gard. **25**: 194, 195. July, 1924.

Summer work with irises. Jour. N. Y. Bot. Gard. **25**: 196, 197. July, 1924.

Acer rubrum. Red maple. Addisonia **9**: 19, 20, *pl. 298*. July 30, 1924.

Botany of Porto Rico and the Virgin Islands. Descriptive flora.—Spermatophyta (continued). (With Percy Wilson.) N. Y. Acad. Sci. Surv. Porto Rico **5**: 475-626. November 8, 1924.

Asterandra grandifolia. Tobillo. Addisonia **9**: 41, *pl. 309*. November 15, 1924.

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Botany of Porto Rico and the Virgin Islands. Descriptive flora.—Spermatophyta (continued). (With Percy Wilson.) N. Y. Acad. Sci. Surv. Porto Rico **6**: 1-158. January 14, 1925.

The pinetum, the collection of evergreen trees. Jour. N. Y. Bot. Gard. **26**: 1-3. "January" [February] 1925.

Resignation of Doctor Murrill. Jour. N. Y. Bot. Gard. **26**: 13. "January" [February] 1925.

El plantel del servicio forestal de Puerto Rico. Revista Agr. Puerto Rico **14**: 83, 84. February, 1925.

Botany and horticulture of Porto Rico and the Virgin Islands. Jour. N. Y. Bot. Gard. **26**: 97-102. May, 1925.

The Charles Patrick Daly and Maria Lydig Daly Fund. Jour. N. Y. Bot. Gard. **26**: 161. July [25], 1925.

Report of the Secretary and Director-in-Chief for the year 1924. Bull. N. Y. Bot. Gard. **13**: 7-17. July 30, 1925.

Barleria Prionitis. Prionitis. Addisonia **10**: 17, *pl. 329*. August 6, 1925.

Urena lobata. Cadillo. Addisonia **10**: 19, *pl. 330*. August 6, 1925.

Erythrina Poeppigiana. Bucare. Addisonia **10**: 21, *pl. 331*. August 6, 1925.

Byrsonima Horneana. Mrs. Horne's byrsonima. Addisonia **10**: 23, *pl. 332*. August 6, 1925.

Tabebuia haemantha. Roble colorado. Addisonia **10**: 25, *pl. 333*. August 6, 1925.

Barbieria pinnata. Enredadera. Addisonia **10**: 27, *pl. 334*. August 6, 1925.

Chamaecrista mirabilis. Porto Rico partridge-pea. Addisonia **10**: 29, *pl. 335*. August 6, 1925.

Distictis lactiflora. Liana fragrante. Addisonia **10**: 31, *pl. 336.* August 6, 1925.

Botany of Porto Rico and the Virgin Islands. Descriptive flora.—Spermatophyta (continued). (With Percy Wilson.) N. Y. Acad. Sci. Surv. Porto Rico **6**: 159-316. August 31, 1925.

Third grant from income of the Charles Budd Robinson Memorial Fund. Jour. N. Y. Bot. Gard. **26**: 195, 196. September [30], 1925.

The American oaks. Jour. N. Y. Bot. Gard. **26**: 205. September [30], 1925. (Review.)

The tree-cactuses of the West Indies. (With Joseph Nelson Rose.) Jour. N. Y. Bot. Gard. **26**: 217-221. October, 1925. [Illust.]

### *1926*

An attempt to aid the natural propagation of hemlocks. Jour. N. Y. Bot. Gard. **27**: 6-9. January [21], 1926.

Bequest of Helen C. Inslee. Jour. N. Y. Bot. Gard. **27**: 17, 18. January [21], 1926.

A dwarf plantation. Jour. N. Y. Bot. Gard. **27**: 25-29. February [10], 1926.

Tree-ferns in Porto Rico. Jour. N. Y. Bot. Gard. **27**: 88-90, *f. 4.* April [16], 1926.

Further botanical investigation in Porto Rico. Jour. N. Y. Bot. Gard. **27**: 97-102. May [27], 1926.

Report of the Secretary and Director-in-Chief for the year 1925. Bull. N. Y. Bot. Gard. **13**: 95-108. June 3, 1926.

Botany of Porto Rico and the Virgin Islands. Descriptive flora.—Spermatophyta, with appendix (concluded). (With Percy Wilson.) N. Y. Acad. Sci. Surv. Porto Rico **6**: 317-371. June 15, 1926.

Osmia borinquensis. Porto Rico osmia. Addisonia **11**: 9, *pl. 357.* June 30, 1926.

A portrait of Mrs. Daly. Jour. N. Y. Bot. Gard. **27**: 135. June [30], 1926.

Doctor William E. Wheelock. Jour. N. Y. Bot. Gard. **27**: 186. August [7], 1926.

The swamp cypresses. Jour. N. Y. Bot. Gard. **27**: 205-207. September [27], 1926.

Fourth grant from the income of the Charles Budd Robinson Fund. Jour. N. Y. Bot. Gard. **27**: 234. October [15], 1926.

Studies of West Indian plants.—XIII. Bull. Torrey Club **53**: 457-471. October 30, 1926. Also as Contr. N. Y. Bot. Gard. no. 284.

The American species of Stipa. Torreya **26**: 93-95. October 30, 1926. (Review.)

The David Lydig Fund. Jour. N. Y. Bot. Gard. **27**: 251, 252. "November" [December 4] 1926.

Teedia lucida. Shining teedia. Addisonia **11**: 37, *pl. 371.* December 9, 1926.

*1927*

Ipomoea quinquefolia. Small white morning-glory. Addisonia **11**: 63, *pl. 384*. January 5, 1927.

The William R. Sands Fund. Jour. N. Y. Bot. Gard. **28**: 23. January [28], 1927.

The Henry Iden Fund. Jour. N. Y. Bot. Gard. **28**: 45, 46. "February" [March 3] 1927.

A portrait of Judge Charles P. Daly. Jour. N. Y. Bot. Gard. **28**: 46. "February" [March 3] 1927.

Studies of the mimosas. Jour. N. Y. Bot. Gard. **28**: 67, 68. March [16], 1927.

The Darius Ogden Mills Fund. Jour. N. Y. Bot. Gard. **28**: 68, 69. March [16], 1927.

The Addison Brown Fund. Jour. N. Y. Bot. Gard. **28**: 89, 90. April [13], 1927.

Trees of Coamo Springs Hotel. 1-14. April, 1927. Los arboles de los Baños de Coamo. 1-15. April, 1927.

The Maria De Witt Jesup Fund. Jour. N. Y. Bot. Gard. **28**: 119, 120. May [17], 1927.

Report of the Secretary and Director-in-Chief for the year 1926. Bull. N. Y. Bot. Gard. **13**: 181-190. June 8, 1927.

Further botanical studies in Porto Rico. Jour. N. Y. Bot. Gard. **28**: 125-131, *f. 1, 2*. June [10], 1927.

The Fanny Bridgham Fund. Jour. N. Y. Bot. Gard. **28**: 148, 149. June [10], 1927.

Sabinea punicea. Caracolillo. Addisonia **12**: 21, *pl. 395*. June 30, 1927.

Angelonia salicariaefolia. Angelon. Addisonia **12**: 23, 24, *pl. 396*. June 30, 1927.

Planting of young hemlocks in the Hemlock Grove. (With Barrington Moore.) Jour. N. Y. Bot. Gard. **28**: 172, 173. July [9], 1927.

Bequest of Dr. George Newton Best. Jour. N. Y. Bot. Gard. **28**: 173, 174. July [9], 1927.

Opening address [at the International conference on flower and fruit sterility, August 12-14, 1926]. Mem. Hort. Soc. N. Y. **3**: 1. July, 1927.

The Francis Lynd Stetson Fund. Jour. N. Y. Bot. Gard. **28**: 200. August [5], 1927.

Stahlia monosperma. Cobana negra. Addisonia **12**: 33, 34, *pl. 401*. October 28, 1927.

Exogonium arenarium. Cambustera. Addisonia **12**: 35, *pl. 402*. October 28, 1927.

Niopa peregrina. Cojobana. (With Joseph Nelson Rose.) Addisonia **12**: 37, *pl. 403*. October 28, 1927.

Erythrina Corallodendrum. Coral tree. Addisonia **12**: 39, *pl. 404*. October 28, 1927.

Chamaefistula antillana. Hediondilla. (With Joseph Nelson Rose.) Addisonia **12**: 41, *pl. 405*. October 28, 1927.

Canavali maritima. Bay bean. Addisonia **12**: 45, *pl. 407*. October 28, 1927.

The Iris Garden entrance and boundary fence adjoining. Jour. N. Y. Bot. Gard. **28**: 266, 267. November [10], 1927.

Charles Frederick Rand. Jour. N. Y. Bot. Gard. **28**: 302, 303. December [27], 1927.

### *1928*

Doctor W. Gilman Thompson. Jour. N. Y. Bot. Gard. **29**: 13, 14. January [28], 1928.

Mimosaceae. (With Joseph Nelson Rose.) N. Am. Flora **23**: 1-76. February 11, 1928.

Resolutions relative to the services of Doctor Frederic S. Lee to the New York Botanical Garden. Jour. N. Y. Bot. Gard. **29**: 42, 43. February [16], 1928.

Forestry and agriculture in Porto Rico. Jour. N. Y. Bot. Gard. **29**: 101-104. May [12], 1928.

Report of the Secretary and Director-in-Chief for the year 1927. Bull. N. Y. Bot. Gard. **13**: 257-260. May 31, 1928.

The John Innes Kane Fund. Jour. N. Y. Bot. Gard. **29**: 210, 211. August [16], 1928.

Mimosaceae (continuatio). (With Joseph Nelson Rose.) N. Am. Flora **23**: 77-136. September 25, 1928.

Bequest of the Burgess collection of asters. Jour. N. Y. Bot. Gard. **29**: 267, 268. October [20], 1928. Reprinted in Torreya **28**: 100, 101. November 16, 1928.

The herbarium of Eugene A. Rau. Jour. N. Y. Bot. Gard. **29**: 284, 285. November [30], 1928.

Mimosaceae (conclusio). (With Joseph Nelson Rose.) N. Am. Flora **23**: 137-194. December 20, 1928.

Ipomoea polyanthes. Yellow morning-glory. Addisonia **13**: 49, *pl. 441*. December 31, 1928.

Jussiaea angustifolia. Yerba de clavo. Addisonia **13**: 51, *pl. 442*. December 31, 1928.

Tetrazygia elaeagnoides. Cenizo. Addisonia **13**: 53, *pl. 443*. December 31, 1928.

Chamaecrista Swartzii. Tamarindillo. Addisonia **13**: 55, *pl. 444*. December 31, 1928.

Columnea Tulae. Tibey parasitico. Addisonia **13**: 57, *pl. 445*. December 31, 1928.

Rubus rosaefolius. Mountain raspberry. Addisonia **13**: 59, *pl. 446*. December 31, 1928.

Volkameria aculeata. Prickly myrtle. Addisonia **13**: 61, *pl. 447*. December 31, 1928.

Pentarhaphia albiflora. Porto Rico pentarhaphia. Addisonia **13**: 63, *pl. 448.* December 31, 1928.

*1929*

[Botanical nomenclature.] Proc. Internat. Congr. Pl. Sci. Ithaca. 1569, 1570. [April] 1929.

Further studies in Porto Rico. Jour. N. Y. Bot. Gard. **30**: 101-105. May [14], 1929.

Report of the Secretary and Director-in-Chief for the year 1928. Bull. N. Y. Bot. Gard. **13**: 351-354. May 31, 1929.

The shrub yellow-root. Jour. N. Y. Bot. Gard. **30**: 265-269, *f. 1.* November [14], 1929.

Pseudocopaiva Britton & Wilson, gen. nov. (With Percy Wilson.) Trop. Woods **20**: 28. December 1, 1929.

*1930*

The planting of a Stahlia on Arbor Day in Porto Rico. Jour. N. Y. Bot. Gard. **31**: 45-47. "February" [March 13] 1930.

The native Cactaceae of Porto Rico and the Virgin Islands. Jour. Cact. Succ. Soc. Am. **1**: 226-231. June, 1930.

Scientific Survey of Porto Rico and the Virgin Islands. Jour. N. Y. Bot. Gard. **31**: 161-167. July [21], 1930.

Texas cacti. Jour. Cact. Succ. Soc. Am. **2**: 285, 286. August, 1930. (Review.)

Scientific survey of Porto Rico and the Virgin Islands. Rev. Obr. Publ. Puerto Rico **7**: 242-245, *map.* September, 1930.

The cacti of Cuzco. Jour. Cact. Succ. Soc. Am. **2**: 308. September, 1930. (Review.)

Foreword. In: Houghton, Arthur Duvernoix. The cactus book. vii, viii. October, 1930.

Sabinea florida. Watapama. Addisonia **15**: 33, 34, *pl. 497.* October 25, 1930.

Corynella paucifolia. Retama. Addisonia **15**: 35, 36, *pl. 498.* October 25, 1930.

Jacquemontia subsalina. Subsaline jacquemontia. Addisonia **15**: 37, *pl. 499.* October 25, 1930.

Proustia Krugiana. Consul Krug's proustia. Addisonia **15**: 39, *pl. 500.* October 25, 1930.

Cestrum laurifolium. Galan del monte. Addisonia **15**: 41, *pl. 501.* October 25, 1930.

Acnistus arborescens. Gallinero. Addisonia **15**: 43, *pl. 502.* October 25, 1930.

Anoda acerifolia. Violeta. Addisonia **15**: 45, *pl. 503.* October 25, 1930.

Mentzelia aspera. Pegadora. Addisonia **15**: 47, *pl. 504.* October 25, 1930.

Krameriaceae. N. Am. Flora **23**: 195-200. November 18, 1930.

Caesalpiniaceae. (With Joseph Nelson Rose.) N. Am. Flora **23**: 201-268. November 18, 1930.

Note on Consolea corallicola Small. Jour. Cact. Succ. Soc. Am. **2**: 347, 348. November, 1930. [Illust.]

Caesalpiniaceae (conclusio). (With Joseph Nelson Rose.) N. Am. Flora **23**: 269-349. December 6, 1930.

Botany of Porto Rico and the Virgin Islands. Supplement to the descriptive flora—Spermatophyta. Bibliography—Spermatophyta and Pteridophyta. Index to Volume V and VI. (With Percy Wilson.) N. Y. Acad. Sci. Surv. Porto Rico **6**: 523-663. December 19, 1930.

### *1931*

Note on Pilocereus Straussii. Jour. Cactus Soc. Am. **2**: 397. January, 1931.

Notes on Byrnesia Weinbergii. Jour. Cact. Succ. Soc. Am. **2**: 414. February, 1931.

The Cactaceae of Tehuacan. Jour. Cact. Succ. Soc. Am. **2**: 422. March, 1931. (Review.)

Additions to knowledge of Mexican Cactaceae. Jour. Cact. Succ. Soc. Am. **3**: 22. August, 1931. (Review.)

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# WILLIAM KEITH BROOKS

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# WILLIAM KEITH BROOKS.*

## ANCESTRY AND FAMILY.

William Keith Brooks, Professor of Zoology in the Johns Hopkins University, was born at Cleveland, Ohio, March 25, 1848, and died at his country home, "Brightside," near Baltimore, November 12, 1908.

Although Professor Brooks used to say jocosely that his known line of descent was too short to be of much interest to a student of phylogeny, it goes back, nevertheless, to some of the earliest settlers of Massachusetts. On his father's side he was descended from Thomas Brooks, who came from England to Boston prior to 1634, and soon thereafter settled in Concord. For five generations preceding the Revolution the Brooks homestead was in Concord. His great grandfather, Joshua Brooks, served in the battle of Concord; his grandfather, Joshua Brooks, was born in Lincoln, Massachusetts, in 1780, whence he removed to Burlington, Vermont; his father, Oliver Allen Brooks, was born in Middlebury, Vermont, in 1814, and moved to Cleveland, Ohio, in 1835, where he became one of the early merchants of that city.

Through his mother he was descended from John Kingsley, who came from England to Dorchester, Massachusetts, about 1638. His maternal grandfather, the Rev. Phineas Kingsley, was born in Rutland, Vermont, in 1788, and moved to Ohio in 1847; his mother, Ellenora Bradbury Kingsley, born June 30, 1817, was married in 1840 to Oliver Allen Brooks, of Cleveland. The parents of Professor Brooks were second cousins, both of his grandmothers having been cousins of the name of Keith, and descended from the Rev. James Keith, who came from Scotland to Boston in 1662, and became the first settled minister of Bridgewater, Massachusetts.

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* In the preparation of this memoir the writer has had the invaluable assistance of Mr. Oliver K. Brooks and Prof. E. A. Andrews. The former has supplied all information available concerning the ancestry and early life of his brother, and he has also furnished certain details concerning his later life and personal traits. Professor Andrews has assisted materially in the compilation of the bibliography, and a free use has been made of his several articles on Professor Brooks.

Although the genealogy of Professor Brooks is thus known for eight generations, the characteristics of his ancestors are not sufficiently well known to justify an attempt to study his heredity. Most of his immediate ancestors in this country were farmers, but his maternal grandfather, the Rev. Phineas Kingsley, was a Congregational clergyman. He had only a common-school education, and had studied theology under a local clergyman, but he was a studious, well-informed man; he had a fund of knowledge about animals and plants, derived from his own observations, rather than from reading, and it is not improbable that his conversation and example may have turned his grandson's attention to the study of living things.*

William Keith Brooks, the subject of this memoir, was the second son of Oliver Allen and Ellenora (Kingsley) Brooks. He had three brothers, all of whom survive him; the oldest, Oliver Kingsley Brooks, born May 21, 1845; the third son, Charles Ernest Brooks, born March 30, 1851; the youngest, Edward Howard Brooks, born November 21, 1854.

Professor Brooks married, on June 13, 1878, Amelia Katherine Schultz, daughter of Edward Thomas Schultz and Susan Rebecca (Martin) Schultz, of Baltimore. To them two children were born, Charles Edward Brooks, August 26, 1879, and Manetta White Brooks, April 21, 1881; the former, after finishing his undergraduate course, took the degree of Ph. D. in mathematics at the Johns Hopkins University, and is now devoting himself to research in that subject; the latter is a graduate of Vassar College, and after the death of her mother in 1901, took charge of her father's home and became his daily companion; in 1909 she married J. Frank Daniel, Bruce Fellow in Biology in the Johns Hopkins University.

Professor Brooks rarely spoke of his ancestry or early life, and for the following illuminating account of his boyhood.

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* William L. Kingsley, long-time Treasurer of Yale College, was a cousin of Phineas Kingsley.

which I have taken the liberty of editing and arranging, I am indebted to his brother, Oliver K. Brooks.

## EARLY HISTORY OF W. K. BROOKS.

By Oliver K. Brooks.

### EARLY DAYS IN CLEVELAND.

"The conditions in which my three brothers and I spent our childhood and youth were almost ideal. Our father lived on lower Euclid avenue, then one of the pleasantest and most agreeable residence sections of the city, now entirely given up to business. We had congenial neighbors, most of whom lived near us for a long time. Many of them had children of about our own ages who were our friends and companions.

"We lived in a large, comfortable, and substantial old frame house with large grounds, especially in the rear, where there was an apple and pear orchard and a hickory tree, reminders of the time when the place was country property, or perhaps part of a farm.

"Near the house was a builders' lumber yard, which was a favorite playground for us, and near by, in another direction, was a convent of Ursuline nuns, with extensive buildings and grounds, separated from the street by a high brick wall. This convent was a place of mystery to us.

"We had an indulgent father and a devoted mother, and an aunt, my mother's sister, who lived with us as one of the family until she married, and until some time after, when her husband, Mr. Warner, bought a house nearly opposite our own. Their house was always like a second home to us.

"My mother's father and mother lived on a small farm some five or six miles south of the city on the Columbus road. He was a retired Congregational clergyman, but he never had a church of his own after he came to Ohio, but used to preach in neighboring towns when he was needed.

"It was a great delight to us to visit our grandfather's farm, and I and my brother William used to spend Saturdays and holidays there. Grandfather used to entertain us with stories of his life in Vermont and of the pioneer days there. He had seen military service in the days preceding the War of 1812.

He had an excellent memory, and was a very good story teller. He taught us to fish, and used to take us on nutting expeditions in the fall.

"Talks with him may have had something to do with turning my brother's thoughts to the study of animated nature. He had in his small library two books—"Thompson's History of Vermont" and the "Philosophy of Natural History," by Smellie—in both of which I know my brother was interested. The first contained an account of the fauna and flora of Vermont, and served my brother as a sort of text-book. I have the book in my possession now, and in it my brother has marked the birds and other creatures which he had found about Cleveland. In some cases he had indicated where the specimens were found.

"My uncle, Mr. Warner, noticed my brother's taste for the study of animals, and encouraged it, and gave him a copy of "Wood's Natural History" as a Christmas present in 1862. While still a schoolboy my brother sent to a sporting paper called "Wilkes' Spirit of the Times," an interesting account of the intelligent conduct of a little dog which belonged to his grandfather. The account, I believe, was headed "Do Animals Reason," and was in the form of a letter to the paper, and was either not signed or only signed with initials. Our uncle discovered it in the paper, and guessed that it was written by my brother, and he "owned up" on being spoken to about it. I think this was his first appearance in print.

"One of our neighbors was the geologist, Prof. J. S. Newberry, afterwards of the School of Mines, Columbia College. He had several sons who were companions and playmates of my brother, and I think they used to go on excursions into the country and collect specimens together. Doctor Newberry had, in a small building near his house, a large collection of fossils and geological specimens, and a knowledge of these may have stimulated my brother to make similar collections. I remember that my brother during his school days read, with a great deal of interest, Hugh Miller's works on Geology, and the works of Doctor Buckland on the same subject, and other books of a similar nature.

"Our mother died after a very brief illness, in June, 1862. My father's mother and sister kept house for him until he married again. His second wife was a widow with a young daughter, who became a member of the family and introduced a new element of interest into our home life.

"The nearby lake, river, and canal were, of course, very attractive to young boys. There was a good bathing beach on the lake shore within walking distance of our house, and we used to go there to bathe during the summer. The river and canal abounded in fresh-water mollusks which were interesting. A part of the river, near where it emptied into the lake, had been cut off by a change of the channel, and was known as the "old river bed." Wild fowl were found there, especially in the spring and fall, and my brother once shot a blue heron there. On one of our trips to the "old river bed" my brother's dog chased some chickens. The owner, an old German, was very angry, or pretended to be, and brought out a shotgun and threatened to shoot the dog. We were thoroughly alarmed, but my brother stooped down without a moment's hesitation and put his arm around his dog and shielded him with his body. He was willing to run the risk of being shot rather than have his pet and companion exposed to danger.

"My brother became interested in aquaria, and had an aquarium in the house and a pond in the yard, stocked with tadpoles, water snails, and small fish. In this pond lived a frog which had learned to come and take flies from his hand. He always had animal pets, which he treated with great kindness; almost always a dog was his companion on his tramps, and he also had pet rabbits, cats, and squirrels. He was very skillful in training animals.

[To his students in after years Professor Brooks occasionally spoke of these early observations and experiments upon animals. In particular he recalled the great flocks of carrier pigeons which at times darkened the sky, and which flew so low after their long southward flight across Lake Erie that they could be struck with poles and clubs as they rose over the bluffs on which Cleveland stands.]

"In imitation, probably, of Professor Newberry's collection, he established a sort of museum in the upper story of the barn back of the house, where he had a collection of shells, fossils, minerals, and geological specimens arranged on shelves, classified and labeled.

"It was probably about this time that he learned to stuff birds, or rather to prepare their skins for preservation. He may have learned to do this from some lectures given by Doctor Kirtland on the subject.

"When he grew old enough to be allowed to do so, he took long tramping expeditions into the neighboring country, sometimes hunting a little, but mostly exploring, observing, and collecting specimens. He formed a friendship with Col. Charles Whittlesey, a geologist and mineralogist, and with him explored and investigated some of the Indian mounds and earthworks in the valley of the Cuyahoga river.

"In his walks and excursions his mind seemed always occupied with problems suggested by what he saw. The commonest objects which most would pass by without a moment's thought set him to thinking and trying to work out explanations of observed features, conditions, and phenomena.

"The first microscope my brother had was made for him by his friend, Mr. Charles F. Brush, the inventor of the Brush electric light. My brother had learned to grind glasses, and devised an ingenious method of making a holder for glass he was grinding. He cut off a piece of broomstick, wrapped paper around it, letting the paper project above the end of the stick, forming a sort of cup or socket. Into this he poured lead, and before the lead had hardened he pressed a marble into it, forming a concavity which served as a socket to hold the glass while being ground.

"Some of the work on the microscope may have been done in the office of Dr. A. Maynard, a retired physician of cultivated and scholarly tastes, who had a fine metal-working lathe which he allowed my brother to use. The Doctor always took an interest in my brother's work and assisted him in many ways. I do not know when my brother first made his acquaintance, but as the Doctor was a friend of my aunt and uncle, Mr. and Mrs. Warner, it was probably at their home that the acquaintance began. The Doctor had a fine library, and encouraged my brother to come to his rooms and make use of his books.

## SCHOOL DAYS.

"My brother received his early education at the public schools of Cleveland. The schools he attended were all within walking distance of our home. He first attended the "Prospect" School, primary and intermediate, quite near home. One of his teachers, a lady, says of him: "I remember him as possessing a most cheerful and loving disposition, and being very bright and quick to learn." From that school he was advanced to the "Eagle" grammar school. The principal was a Mr. Perkins, who was assisted by his wife. They remember him as a good boy of quiet and gentle manners, who never gave them any trouble, but do not recall anything to indicate the ability he afterwards developed. One of his schoolmates there was Prof. Theodore B. Comstock, now of Los Angeles, California, who wrote me as follows:

> William (we called him Will) was fond of animals and was of an investigating turn of mind, as a boy. He knew more of Nature than his associates and took keen interest in what he observed. Reptiles and venomous insects were his pets. His will was strong, but not aggressive. An incident in my experience with him will illustrate this: One day I had teased him, and on our way home he quietly said, "Don't you say that again." I ran off to a safe distance and mocked him. He started for me with doubled fist, showing no emotion, but coming towards me with a steady walk. I dodged him for awhile, and then concluded he had given up the chase, as he did not appear angry and kept up his steady walk. Finally, I came over to him unconcernedly. He walked calmly by my side, raised his arm, and struck me on my shoulder. That was all, but my shoulder was very sore for many days afterwards. Aside from his attachment to animals, I remember nothing in his early youth which could be regarded as clearly indicating his later career.

"He was never a plodding student, his quickness of mind enabling him to grasp a subject rapidly, and when he had once done so he lost interest in its details. From the grammar school he went, in 1863, to the Central High School, which was then quite near our home. The principal there was Dr. Theodore Sterling, afterwards president of Kenyon College, and he was assisted by Professor Norton, now Professor of Chemistry at Ohio State University, at Columbus. Both remember him well. Doctor Sterling wrote me as follows in regard to him:

> I remember he was fond of taking walks in the fields and woods, and collecting and putting in his pocket whatever interested him, whether shells or pebbles or plants or bugs. Sometimes when I met him he would empty his pockets, showing me what he had found and get what information he could from me about whatever excited his interest. This seemed to indicate that his love for natural history was very early developed.

"Professor Norton wrote:

> I do not think that he studied chemistry or Virgil under me, but in all likelihood he was under me in some of his early studies, botany and natural philosophy for instance. As I call him to mind, he was a quiet, studious boy, rather reserved in his manner, and not much given to the ordinary boyhood jokes and games.
>
> The last time I met him, so far as I can recollect, he was engaged in a summer school of natural philosophy in the upper floor of the High School, together with Prof. A. H. Tuttle, now of the University of Virginia. I was much struck with the mastery he exhibited in his school and surprised at his early maturity.

"He went by the name of 'Mummy' among his schoolmates, probably because of his silent habits. At the high school his liking for and ability in mathematics and natural science was notable, and is remembered by his teachers and fellow-students, one of whom was Dr. J. H. Lowman. He and Doctor Lowman took private lessons in Greek from Professor Rueger, who was a teacher of German in the high school, and thereafter this subject had a charm for him second only to that of mathematics and natural science.

"Doctor Lowman remembers his early work with the microscope, and being shown the teeth of a snail and the epithelial cells of tissues, and thinks he worked with the microscope in Doctor Maynard's office.

"My mother had a liking for the fine arts, and had some little native ability in drawing and coloring, although she had had no training, and very little opportunity to cultivate this natural gift. When my brother began to use the microscope, he asked me to show him how to draw the objects he was studying. I gave him a few instructions, but almost from the start he grasped the idea, and soon became very skilful in drawing with the pen. All he seemed to need was a few suggestions to start him right, and he went on without assistance and soon taught himself to make beautiful and elaborate drawings with the pen.

"He had a congenital defect of the heart which prevented his taking any active part in sports at school, but he was fond of playing checkers, and was very expert indeed at the game. A little later—perhaps he was sixteen years old at the time—he took up chess, and gave it serious thought and study. In later life he was an expert whist player, and was rarely, if ever, beaten at the game.

"He organized a society of some of his schoolmates while at the high school, and later one which met in a room in a downtown business block. This society was called "Magnus Pax," and met to read selections and discuss various subjects. There were probably not more than a dozen members, all told.

"He did not graduate at the high school, but left at the end of the third, or junior, year, in 1866, to enter Hobart College.

"I think my father's second wife felt little sympathy with my brother's desire to devote his life to study and research. She may have influenced my father to some degree, and I have no doubt my father was deeply disappointed in not being able to induce my brother to apply himself earnestly to business.

"He may have had a feeling that if he gave his sons a common school education sufficient to fit them to make their way in business, that was enough, and after that they ought to get to work and take care of themselves. He may have looked on a college education as a luxury that might render one unfit for a business career.

"Because of this feeling it was hard for him to sympathize with or encourage my brother's desire to devote himself to a life of study and research. He could not comprehend how a living could be made in that way, and he felt his sons must early find a way to support themselves. While he was ready and willing to assist them in getting a start in life, he probably felt unable to do more than this, and that to do more for one in supporting him while at college might be unjust to the others, or might limit his ability to help them in turn. Still, when he found my brother bent on having a college education, he gave him all the assistance he thought he could afford, and when he achieved success and had recognition, he was very proud of him.

"An old friend of Doctor Maynard, mentioned above, told me the following incident:

"The Doctor told him that my father at one time came to him in a good deal of perplexity, to ask his advice about Will, who had then been taken into his store, but who showed no interest in business and no inclination for it, but, on the contrary, seemed to have his mind occupied with other matters which had no relation to business, and of which my father could not see the use. The Doctor had seen a good deal of Will, and Will had talked with him pretty freely about the subjects and studies which attracted him, and he told my father he thought it was better to let Will follow his evident inclination for a life of study and research, believing he would never adapt himself to a business life, and would only be made unhappy by being confined to an uncongenial occupation, but that he was in no danger of becoming a mere idle loafer, and, on the contrary, had ability which would become evident if he were allowed to follow his inclinations, and that if so allowed the boy would show he had good stuff in him and a mind above the ordinary, and would probably succeed."

## COLLEGE AND UNIVERSITY CAREER.

He entered Hobart College, Geneva, New York, in the fall of 1866, and left at the completion of his sophomore year. His cousin, the Rev. Wm. J. Cleveland, of Bostonia, California, writes: "We were at Hobart College together for some time, and it may have been through my being there and urging him to come that he began his higher studies there." He remembers that he was liked by the best element among his fellow-students for his cheerful, gentlemanly bearing, coupled with a quiet but telling wit. He was not a plodding book slave, but quick of intellect and wide-awake, and he found his recreation more in mental than in physical activity. His son, Dr. Charles E. Brooks, informs me that while his father was a freshman at Hobart he won the White Essay Prize, never before taken by a freshman. That he had already begun to read and appreciate philosophy is shown by the fact that his volume on "The foundations of zoology," published in 1898, is dedicated "To Hobart College, where I learned to study and, I hope, to profit by, but not to blindly follow, the writings of that great thinker on the principles of science, George Berkeley."

Leaving Hobart at the end of his sophomore year, he entered the junior class at Williams College in the fall of 1868. Concerning his life at Williams, Mr. T. H. Brooks, of Cleveland, a lifelong friend, but not a relative, writes:

> I look back over half a century of acquaintance with Prof. William K. Brooks, commencing, of course, at a very early period in our lives. We played together, went to the public school here together, and later were classmates at Williams College, and were both graduated from there in 1870. I never knew him otherwise than kind, gentle, thoughtful, and studious; not demonstrative in his friendships, but thoroughly loyal and sincere. He cared nothing for marks or prizes in college, was very liable to burn the midnight oil over some subject that specially appealed to him, and then "cut" prayers and early recitations the next morning. He never put himself forward to answer the questions of the class room, but when called upon always gave a good account of himself. College boys, so far as my experience goes, take the problems of calculus without question and almost without understanding, but he grasped and was delighted with every proposition, and to the utter amazement of his professors and classmates, discovered a mistake in the text-book used. He was generally acknowledged to have been the most brilliant student in mathematics Williams had ever seen."

His love of the natural sciences was fostered by the Lyceum of Natural History at Williams, an active organization which at one time sent a natural history expedition across South America, and by Sanborn Tenny, botanist and zoologist, under whom he studied. But the history of his whole life indicates that he was not led into the study of zoology by teachers or environment. We may apply to him with especial force the following sentiment from his address before the Seventh International Zoological Congress (p. 34): "Most of us have, no doubt, been drawn to our specialty by the natural bent of our minds, rather than by deliberate choice. The zoologist who best deserves the name is one whose natural bent has been too strong for him, so that he has studied zoology because he could not help it." Prof. E. A. Birge, of the University of Wisconsin, was a freshman at Williams when Brooks was a senior. He remembers that Brooks had a microscope, a rare thing in those days, and that with it he showed many interesting things to his fellow-students, who frequented his room, evenings. On one occasion he undertook to demonstrate a cross-section of a hair, and after much difficulty in trying to cut a free-hand section, he lathered and shaved a portion of his face, and then engaged the students in other things, while he waited a half hour for the hair to grow before he shaved again.

Prof. S. F. Clarke, of Williams College, one of his first students at the Johns Hopkins University, said of him in an obituary notice in the Williams Record:

> His mind was markedly of the philosophical type which appeared even in his college days, when he was known among his classmates as "the philosopher." I remember his saying that there were two things in his college course which were of special interest to him, and which also in the retrospect gave him the most satisfaction: one was solving the problems of Euclid; the other was the study of philosophy under Mark Hopkins.

In 1870 he received the degree of Bachelor of Arts and was elected to the honor society, Phi Beta Kappa. It is probable that at this time he had decided to follow a career of teaching and investigation, but it seems likely that he doubted whether he could find an opportunity to teach natural history, for in after years he said that he was in doubt when he left Williams whether he should teach mathematics, Greek, or biology. However proficient he may have been in the two former, there can be no doubt that by nature, early training, and inclination he was especially fitted for the career which he later entered. As indicating the manner in which he was "finding himself" at this time, the following extract from a letter of his cousin, the Rev. William J. Cleveland, is of interest:

> On another occasion, I think it was in 1869 or '70, after I had graduated, he visited me at Orange, N. J., and was full of the idea of teaching. He had with him a big lot of specimens of one kind and another, and his ambition was to try the experiment of giving public lectures. Enlisting me as assistant in a business way in this enterprise, a hall was engaged and announcements made in a small town "up the road" from Orange. I do not recall whether it was Milburn or Chatham, but at one of them he delivered what, no doubt, was his first public lecture. There was not a big crowd, but my recollection is that there was a very respectable and interested audience, and that all passed off nicely. He was in no sense oratorical or florid, but he went straight to his subject and on with it to the end, relying solely upon the interest of the subject itself, which was so great to him, to hold the attention of the audience.

> I have tried hard, but with very meager results, to recall the topic and subject-matter of the lecture. I feel quite sure now, however, that the subject was "Mollusks," but I remember nothing of what he said except that he spent considerable time, as it seemed to me at the time, in explaining to the audience what Mollusca were.
>
> I believe his only object then was to try the experiment of giving a public lecture and to find out how he stood the ordeal. For that reason, perhaps, he chose a (then) small and out of the way place, and the whole venture was managed in the most quiet and unpretentious way. As I remember, no hand-bills or other printing of advertisements was resorted to to draw a crowd. To give a lecture before a mixed audience in some public place and get enough out of it financially to fairly meet expenses, was all he aimed at. That experience, no doubt, had some influence in convincing him that the class room rather than the platform was the place where he could do his most efficient work.

Following his graduation from college, young Brooks spent the year 1870-71 in business with his father, who was an importer and wholesale dealer in crockery, china, and glassware. Prof. E. A. Andrews, in his biographical sketch (Johns Hopkins University Circular, No. 212, January, 1909), says that during this year "he exhibited characteristic interest in the solution of problems and distaste for such mechanical drudgery as had only practical and not theoretical ends in view, by the invention of a calculating machine to lessen the amount of unprofitable manual labor." There is evidence that he continued his reading and study during this year, as much as his other duties would permit, and he and other young men continued to meet at his club for talks and discussions.

In the fall of 1871 he entered definitely upon his career as a teacher. He was employed as one of the masters at De Veaux College, Niagara Falls, New York, where he remained for two years. His ability to win the confidence, respect, and affection of his students was notable even at this early stage in his career. He had a way of not only interesting his scholars, but also of attaching them to him personally. The Hon. Herbert P. Bissell, of Buffalo, New York, who was a student at De Veaux College at that time, has written the following concerning Professor Brooks:

> I have consulted with several old De Veaux boys, but none of them could add very much to my own knowledge of Professor Brooks. We all remember him as a man devoted to scientific research and constantly

studying the geology, and the flora and fauna along the Niagara River. I recall the interest he would take in any geological specimens that we would find underneath the high bank of the Niagara River. He would give us his opinion promptly as to the geological age to which the specimen belonged, etc. His work at De Veaux College was most satisfactory; he was an excellent and interesting teacher and, as I have intimated, devotedly attached to scientific investigation.

He remained at De Veaux College for two years, and then entered upon the professional course of training in zoology for which he had been planning and preparing. At Harvard, Louis Agassiz was at the climax of his wonderful career, and many young men, who afterward became leaders in biology, went there to study under this great master. In particular in the summer of 1873 the establishment of Agassiz's new seaside laboratory on the island of Penikese, in Buzzards Bay, attracted wide attention. This new departure, the first of the summer schools, was projected by Agassiz in the preceding winter; the island and a fund for the establishment of the school were given by Mr. John Anderson, of New York, in March, and the large buildings were hastily constructed, and were scarcely ready for occupancy when the school opened early in July. Between fifty and sixty teachers and investigators were present, and among these was Brooks. From that time until his death he remained a student of marine life. The sea, with its teeming multitudes of living things, always had a particular charm for him, not merely because of the interest and variety of its forms of life, but also because it was probably the scene of the earliest acts in the drama of evolution.

From this time forward throughout almost his whole life he spent a part, at least, of every summer at the shore. In 1874 he was again at Penikese at the last session of that famous but short-lived laboratory. In 1875 he was with Alexander Agassiz at his private laboratory in Newport, Rhode Island, working on the embryology of Salpa, and tutoring one of Mr. Agassiz's sons. In 1878 began the sessions of the Chesapeake Zoological Laboratory, which he founded and directed for many years. In the summers of 1888 and 1889 he was at the U. S. Fish Commission Laboratory at Woods Hole, Massachusetts, and in later years he was frequently at the Commission's Laboratory at Beaufort, North Carolina. He was a trustee of the Marine Biological Laboratory almost from its foundation until his death. In the summers of 1905 and 1906 he was at the marine laboratory of the Carnegie Institution of Washington, at Tortugas, Florida. His scientific life was thus closely identified with marine laboratories, beginning with the earliest of these at Penikese, and ending with the latest at Tortugas.

In the fall of 1873 he entered the graduate school of Harvard University, where he continued two years, receiving the degree of Doctor of Philosophy in 1875. At Cambridge he came to know several zoologists whose work and influence helped in some measure to shape his career. First among these must be named Louis Agassiz, of whom Brooks occasionally spoke in later life and whose influence upon him was profound though brief. Agassiz died in December, 1873, and Brooks' association with him was thus limited to the summer session at Penikese and the autumn term at Harvard. Among others whose influence he felt must be mentioned Alexander Agassiz, McCrady, and Hyatt.

While at Harvard Brooks and some other young zoologists lived in an old wooden building known as Zoological Hall, which stood where the Peabody Museum now stands. Professor Birge, who lived in the same building and thus saw Brooks frequently, remembers that he lived very simply and was apparently supporting himself, and that his usual carelessness of dress was emphasized by the fact that he mended his torn clothes with white string. His life was studious and generally solitary, save for the companionship of a great St. Bernard dog, "Tige," who always walked with him when he went out and who occupied most of his bed at night. "I hardly think," says Professor Birge, "that any of his ideals were shaped by the men with whom he worked. He read much and thought for himelf. One day he brought me a new copy of Darwin's Origin of Species, and when I asked him what this meant, he told me that he had borrowed mine one day when I was out, and, having kept it a good while, had written so many notes in it that he preferred to buy me a new copy rather than give the old one back."

In the summer of 1875, after his graduation from Harvard and before his visit to Mr. Agassiz's laboratory at Newport, in August and September of that year, he was instrumental in organizing a laboratory for instruction in Biology in Cleveland. As no fees were charged for this course it seems probable that his purpose was to gain experience in teaching, as well as the purely disinterested aim of establishing an inland Penikese for the instruction of teachers and students of natural history. In his address at the dedication of the new biological laboratory of Western Reserve University, in 1899, he described that enterprise in the following words:

> It was my good fortune to have a share in one of the first attempts to organize laboratory instruction in Cleveland, and I hope you will pardon me if, on this occasion, my mind runs back to this old undertaking. In 1875 three young men who had begun to train themselves as naturalists, came together for their summer vacation, at their homes in Cleveland. They were Theodore B. Comstock, afterwards President of the University of Arizona; Albert H. Tuttle, now Professor of Biology in the University of Virginia, and myself. We were filled with enthusiasm for our work, and, like all earnest students from Chaucer's day to this, as glad to teach as to learn, and we determined to organize a summer class for laboratory instruction in zoology and botany. Money for our expenses was liberally supplied by R. K. Winslow, Leonard Case, and other citizens; the authorities granted us the use of the old high-school building on Euclid avenue near Erie street, and we were soon able to issue notices of our undertaking, and invitations to all who wished to join the class, asking them to do so without the payment of any fee. Some twenty-five were soon enrolled, most of them teachers, some from a distance, and work was begun with a class which shared all the earnestness and enthusiasm of their instructors. We had daily lectures or demonstrations, followed by four or five hours of work in the laboratory, while two afternoons in each week were given to excursions to Rocky River, Cuyahoga Falls, and other places favorable for the out-of-door study of nature. As a small steamboat had been placed at our service, we made two excursions upon the lake, and thus gave to the class an opportunity to learn the use of the naturalist's dredge for collecting the animals of the bottom. Our work was in part the study of the animals and plants which we obtained on these expeditions, and we also made use of a supply of marine animals which had been gathered for the purpose at the seashore.

This account is interesting not merely as a bit of local history, but rather because it reveals thus early in his career his love of teaching and his methods of instruction; the latter, we may be sure, largely influenced by his experience at Penikese.

During the year 1875-76 Brooks was assistant in the museum of the Boston Society of Natural History. This was practically his only experience in museum work. He was not a museum man, being one of the first zoologists in this country to demonstrate in practice that the museum is distinctly inferior to the laboratory as a means of teaching and research. Apart from a small teaching collection he undertook to establish no museum at the Johns Hopkins University, and such collections as he had were for use rather than for exhibition. If a student needed for the sake of his research to dissect a museum specimen, he might feel certain that Doctor Brooks would offer no objection. He appeared to be wholly lacking in that reverence for specimens as such, which the typical museum man is supposed to have. Some of his early students who had been trained in the museum methods then prevalent at some of our oldest and largest universities have confessed that 'when they went dredging with Brooks it made their hair stand on end to see the way in which he chucked material overboard.' With him research was the all-important thing, to which collecting and collections were always subordinate. The writer remembers that on one occasion he brought a distinguished medical man into the students' laboratory in Baltimore, and after showing him a series of sections of a larval Amblystoma, said to him: "Here is a little piece of glass which you can carry in your vest pocket, and which is worth more to one who wishes a knowledge of anatomy than a whole museum full of specimens."

On the founding of the Johns Hopkins University in 1876 Brooks applied for and obtained one of their twenty famous fellowships, which have done so much to change the character of university work and ideals in this country. Before he entered upon his fellowship his abilities as a teacher were recognized and he was appointed associate in biology. In 1883 he was appointed associate professor of morphology, and in 1889 professor in that subject. On the retirement of Prof. H. Newell Martin from the headship of the biological department in 1894, Professor Brooks became head of the department and continued in that position until his death. His active scientific life was therefore coextensive with that of the Johns Hopkins University, and his love of the biological department, and his loyalty to his university were always evident.

## CHARACTERISTICS AS TEACHER AND INVESTIGATOR.

Although his publications were numerous and important, I think that his influence was greatest and most far-reaching in his work as a teacher and scientific director. To few zoologists, perhaps to no other in the history of this country, has it been given to direct the work and shape the scientific ideals of so large and influential a body of young men. Among those who took their doctor's degrees under him are more than a score of the leading zoologists of this country, while many other distinguished scholars of this and foreign lands were his pupils.

As a teacher, Professor Brooks was characterized by his breadth of view and his interesting and illuminating style, rather than by his accuracy in details. Like all great teachers, he knew that the primary purpose of teaching is inspiration and illumination, and that information is only of secondary importance. A candidate for the doctor's degree expressed to Professor Brooks, on the morning after his major examination, his mortification that he had blundered in answering one of the questions. With apparent seriousness Brooks said: "Your mistake is a serious one, for it makes you responsible for misinforming my whole class on that subject; I used your answer in my lecture this morning."

His lectures were often vivid and picturesque, as well as clear and logical; and this, joined with his habit of taking little for granted on the part of his hearers and of dealing with the broader and more general phases of a subject, made his lectures interesting not only to biologists, but also to those having no special knowledge of the subject. He invariably lectured without notes, and yet his lectures were so orderly and logical that they bespoke the logical character of his mind. Professor Howell in his memorial address (Johns Hopkins University Circular, No. 212, January, 1909) said, with regard to this, that "when it was known that Brooks was to give a paper before the scientific association of the university it was a custom for men in all the graduate departments to attend the meeting, so much did they appreciate the charm and clearness with which he could present the problems of his subject." I well remember the first time I saw and heard him; it was on the occasion of the annual opening of the graduate school in the fall of 1888. His appearance was neither impressive nor prepossessing, but when he began to speak the closest attention was paid to him. In fascinating terms he described the beauties of the Bahama Islands, with their cocoanut palms and coral reefs; and I shall never forget the enthusiasm and the calm but almost dramatic manner with which he described the finding of the eggs of Gonodactylus in the twilight of his first day in the Bahamas. Equally vivid are the memories in the minds of all his students of his description of the way in which a starfish eats an oyster; of the comparison of a starfish with a sea urchin; of the structure and movements of a jelly fish; of the structure of a squid (in which his own body represented the visceral mass and his coat the mantle); of Salpa, "a barrel with muscular hoops," or Pyrosoma, which at night looked like "a redhot cannon ball." Most delightful, too, were his references to the history of zoological discovery, as, for example, Aristotle's knowledge of the relationships between the various members of a colony of bees, or Chamisso's discovery of the supposed alternation of generations in Salpa.

His blackboard drawings added very much to the interest and value of his lectures; with a firm, even hand he would sketch the form he was describing, and he rarely needed any other eraser than his forefinger. He had learned, early in life, to draw on the blackboard with both hands, by observing the work of Prof. E. S. Morse, while lecturing in Cleveland. He was really an artist of considerable ability and his published drawings were made with much care; in general, they were not only accurate, but also artistic. He was a great believer in pen and ink drawings, and the time and care which he devoted to putting in round and equidistant stipples seemed excessive, until one learned that these were times of reflection with him. His fondness for innovation was shown by his adoption, at one time, of a method of drawing with lithographic pencils on paper, which drawings were then transferred directly from the paper to the stone. In later years he made much use of sepia washes, and he had all his students using them. He expected all his students to learn to draw; to some of them he would say time and time again, "You'd better learn to draw," apparently unmindful of the fact that he had given this advice before, and that they were trying to learn as rapidly as possible; and sometimes, when shown a drawing of which the maker was rather proud, his only comment would be, "You can't do anything well without patience."

He loved to work with simple apparatus, and his technique was never complicated. He never mistook paraphernalia for science, and he went directly to the end he sought. He had a great fondness for primitive methods, and used to advise his students to learn to cut free-hand sections, and to use some of the oldest methods of staining and imbedding. At one time he had some of his students repeating ancient history in trying to imbed tissues in soap, and to more than one who asked him for advice about staining microscopical preparations he recommended Beale's Carmine; the results were always unsatisfactory, but in the meantime the student had learned something about the historical development of staining methods, and, best of all, had also learned to rely upon himself rather than upon Doctor Brooks. One such student, after laboring for some weeks with Beale's Carmine, saw Doctor Brooks and told him that he could not get satisfactory results. After waiting in vain for some response, he ventured to ask whether Doctor Brooks had ever used the method. Yes, he had. "What did you think of it?" "'Twasn't worth a damn." Not infrequently, when students asked him to suggest some topic for research work, he would recommend some wholly impractical thing, such as the study of siphonophores at Woods Hole or the study of Amphioxus at Beaufort; and such students were left to find their own problem and to work out their own salvation.

Although he would present a subject in his lectures in the clearest and most entertaining manner, he rarely, if ever, attempted to smooth the path of the investigator; the latter was to a very large extent thrown upon his own resources. He believed so thoroughly in the law of natural selection, as he once said, that he thought it was best for a student to find out for himself, as soon as possible, whether he was fitted for independent investigation or not, and by this rigid discipline the unfit were weeded out from the fit. This was certainly no school for weaklings, but it afforded magnificent training for those who had ability and determination. For those who endured this ordeal he maintained the warmest regard, and his interest and pride in the work of his students was as marked as it was stimulating.

Throughout the greater part of his life he did most of his research work at night; even the preparation and study of microscopical objects were frequently done by lamplight. He was quite proud of a little device of his by means of which he could imbed objects in paraffin by the heat of his student lamp, which served to illuminate his microscope. It was his custom, after his day's work at the university, to spend the evening with his family, frequently in reading aloud or in playing cards, and then, after all others had retired, he began his work. With his feet wrapped up in blankets to keep them warm he would write, or use his microscope, far into the night. In his work at the shore he would work all day, or all night, as the need might require or his inclination prompt. In his last years night work was no longer possible for him, and he turned to music for recreation, having discovered almost by accident that he had a great fondness for music, and that this liking could be gratified by means of an automatic piano. The last time I saw him we sat up until after midnight playing compositions by great musicians.

In spite of the fact that he was, during the course of his life, interested in many things, he was rarely interested in more than one thing at a time; and this sometimes led to an apparent lack of sympathy with the work of some of his students which was more apparent than real. Occasionally, when he was appealed to for some explanation of some published statement of his, he would say, "I have forgotten all about that now." Often when asked a question, he would say, "I don't know," when he knew better than anyone, although, at the time, the subject was out of his mind. To one of his students who was at work upon a cytological problem, he mildly protested that such work was not morphology; and to one who offered him a thesis on cell-lineage, he remarked, "This university has accepted theses on counting words; I suppose it might accept one on counting cells."

But though he sometimes disagreed with the conclusions of his students, he never attempted to dictate to them. They were treated as absolutely free and independent investigators, and he usually assumed no responsibility for their work or results.

He lived with his students on terms of comradeship. Indeed, between himself and them there existed a real but undemonstrative affection, which was shown on his part, not merely by solicitude for their safety when they were in danger, but by many little kindnesses at the laboratory and in his home. In particular he used to refer with pride and sorrow to those of his students who had died: Rice, Bruce, Humphrey, and Conant. On one of my visits to Baltimore he led me without a word to the tablet which had been placed on the wall of the laboratory in memory of Humphrey and Conant, both of whom lost their lives of yellow fever on their expedition to Jamaica in 1897. We both stood and silently read the tablet, and then as we turned away he said, simply but with emotion, "I thought you would like it." When once relations of comradeship had been established with his students, neither time nor separation changed these relations, and they never needed to be renewed. When attending the International Zoological Congress in Boston, he saw in the hotel lobby a former student whom he had not seen for nine years. He spent no time in renewing acquaintance, but went up to him, as if there had been no break in their associations, and said, "Do you know where I can get a shoestring?" There was a sort of helplessness or lack of worldly wisdom on his part which made his students feel responsible for him, and which increased their affection for him. His interest in his former students was genuine and hearty, though he rarely expressed it to the person concerned. He did not lose his critical judgment in his affection for his students, though he often showed that he was proud of their accomplishments. "One of the joys of a teacher," he once said, "is to see his students surpass him." On the other hand, his students delighted to honor him; and on the occasion of his promotion to a full professorship, on his fiftieth birthday, at the twenty-fifth anniversary of the founding of the Johns Hopkins University, and at the International Zoological Congress in Boston, they showed him how deep a place he held in their affections. On December 31, 1908, sixty of his former students met at a dinner in Baltimore to pay honor to his memory, and the occasion was one of delightful reminiscence and of grateful recognition of indebtedness to him.

## THE CHESAPEAKE ZOOLOGICAL LABORATORY.

In connection with his work as teacher and director must be mentioned the establishment by him of the Chesapeake Zoological Laboratory in 1878. The great influence which his experience at Penikese had upon him has already been mentioned. To a large extent the direction and character of his research work was determined by this experience, and its influence was apparent in all his teaching as well as in his research. We have seen that it led him to organize a second "Penikese" at Cleveland in the summer of 1875, and one of his first acts at the Johns Hopkins University was the organization of the Chesapeake Zoological Laboratory. The stimulating influence which this laboratory had upon the research work of Doctor Brooks is shown by his bibliography, where it may be seen that after the first session of that laboratory his annual output of work was increased at least fourfold. And the importance of the laboratory in the development of the biological department of the Johns Hopkins University and in the general advance of zoology in America may be estimated from the large number of students who worked at the laboratory and the large number of papers which they published. Doctor Brooks expected all of his graduate students to spend a season or more at this laboratory. He rightly estimated this as the most valuable experience a student of zoology could have, for in this way the student became acquainted with animals under natural conditions; he had opportunities of becoming a broadly trained naturalist, and he could find his own problems for work and become an independent investigator.

The Chesapeake Laboratory, unlike the one at Penikese, was not limited to one place; it consisted neither of buildings nor equipment, but of men and ideas. For the first few years of its existence it was located at several different points on Chesapeake Bay; afterwards it was located at Beaufort, North Carolina; then at different places in the Bahama Islands, and finally in Jamaica. In the various expeditions of Brooks and his students to these different places they made not only a thorough biological survey of each region, but they did work of most fundamental and far-reaching importance on the various groups of animals found. Out of these expeditions has grown the beautiful and permanent station of the U. S. Fisheries Bureau at Beaufort, North Carolina, in which Brooks took great interest and pride. It was on these expeditions that his students came to know him most intimately and affectionately. In the memory of each of them is fixed some scene of his enthusiasm over the discovery of a rare specimen or of an unknown stage in some life history; his long vigils full of exciting discoveries; his quiet talks on nature and philosophy, after the day's work was done.

The Chesapeake Zoological Laboratory occupied so large a place in the life and work of Professor Brooks that it seems desirable to reproduce here, in his own words, a more detailed account of the aims and history of that laboratory during its first nine years. The following is taken from a report by Professor Brooks on "The Zoological Work of the Johns Hopkins University, 1878-86," published in the Johns Hopkins University Circulars, Vol. 6, No. 54:

> In natural science the policy of the University is to promote the study of life, rather than to accumulate specimens: and since natural laws are best studied in their simplest manifestations, much attention has been given to the investigation of the simpler forms of life, with confidence that this will ultimately contribute to a clearer insight into all vital phenomena.
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> The oldest forms of life are marine: every great group of animals is represented in the ocean, while many important and instructive groups have no terrestrial representatives; omitting the insects, more than four-fifths of the known species of animals are marine, and the total amount

of animal life in the ocean is incomparably greater than that upon the land. In a word, the ocean is now, as it has been at all stages in the earth's history, the home of life; and it is there, and there only, that we find the living representatives of the oldest fossils, and are thus enabled to study the continuous history of life from its simplest to its most complex manifestations.

On the sand flats at the mouth of the Chesapeake Bay, we find, living side by side, animals like Lingula, Amphioxus, Limulus and Balanoglossus, which are the representatives of some of the oldest and most primitive types of animal life; and all attempts to trace out the natural relationships of any group of animals, lead us at once to forms which are found only in the ocean.

The animals which have contributed most extensively to the formation of the earth's crust, the corals and foraminifera and radiolarians, abound in the ocean today, and it is only by studying their life, by observations at the seashore, that we can understand and interpret their geological influence.

Nearly every one of the great generalizations of morphology is based upon the study of marine animals, and most of the problems which are now awaiting a solution must be answered in the same way.

For these reasons our chief aim in zoology and animal morphology has been to provide means for research upon the marine animals of the Atlantic coast, and for nine years, successive parties, composed of instructors, fellows and students in this department, together with instructors and advanced students from other institutions have spent at the seashore all the months in which marine work is practicable. Their time and energy have been devoted to research rather than to the preservation of collections, and the wisdom of this course can be estimated by examination of the accompanying list of publications; all of which are based, either in part or entirely, upon researches which we have carried on at the seashore.

The wisdom of our policy is well illustrated by the fact that the leading naturalist of America, himself the head of one of the largest scientific collections in the world, says in his annual report for 1884,* that the expenses of an immense natural-history collection are so great that it would be far cheaper, with the present facilities and the cost of travel, to supply the student with the necessary funds for valuable researches, than to go on for years spending in salaries of curators and the care of collections, sums of money which, if spent in a different manner, in promoting original investigation in the field or in the laboratory and in providing means for the publication of such original researches, would do far more towards the promotion of natural history than our past methods of spending our resources.

This fact has become widely recognized during the last ten years, as is shown by the establishment of marine laboratories by several of the

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* Report of the Museum of Comparative Zoology, Cambridge, Mass.

European institutions of learning; and in the summers of 1883 and 1884 we had with us at our laboratory a young English naturalist (Wm. Bateson) who had been provided by the Royal Society of London with funds for his researches, the results of which have recently been published in England.

The Johns Hopkins University was among the first to recognize and act upon this new departure in zoology, and our little marine station is almost as old as the great Naples laboratory. Briefly stated its history is as follows:

In 1878 a small appropriation was made to enable a party of biologists from the University to spend a few weeks at the seashore in the study of marine zoology. Through the influence of Maj. Gen. Q. A. Gillmore, the Secretary of War permitted us to occupy the vacant building at Fort Wool. Prof. Spencer F. Baird also exerted his influence with the Secretary of War in our behalf, and aided us in many other ways; furnishing us with dredging apparatus and with three small row-boats. The scientific results of our season's work were printed in an illustrated volume, the cost of publishing which was borne by the following citizens of Baltimore: Samuel M. Shoemaker, John W. Garrett, John W. McCoy, Enoch Pratt, P. R. Uhler, T. B. Ferguson, Dr. Geo. Reuling, President Gilman, Professor Martin and others.

In 1879 the appropriation for the maintenance of the laboratory was renewed, and in order to present an opportunity for studying the oyster beds of Maryland, the laboratory was opened in three of the barges of the Maryland Fish Commission at Crisfield, Maryland, a point which proved to be very unfavorable. Maj. T. B. Ferguson, the State Fish Commissioner, not only provided the barges for our accommodation, but he also fitted the steam yacht *Lookout* with dredging apparatus, and rendered us valuable help in dredging and collecting. Through his influence a small steam launch was also detailed from the U. S. Navy for our use.

The next year the Trustees of the University voted to continue the laboratory for three years more, 1880–1–2, and they provided a liberal annual appropriation of $1,000 for current expenses, which was renewed annually in 1883–4–5–6, and was expended in rent, wages, fuel, laboratory supplies, repairs, etc. They also appropriated the sum of $4,500 for permanent outfit, and most of this was used in the purchase of two boats; a Herreshoff steam launch twenty-seven feet long and eight feet beam, and a center-board sloop forty-seven feet long and fourteen feet beam.

After an examination of all the available localities the town of Beaufort, N. C., about four hundred miles south of Baltimore, was selected as the site for the laboratory, and a vacant house, suitable for the accommodation of a small party, was found and rented as a laboratory and lodgings for the party, and it has been occupied during the seasons of 1880–1–2–4–5, and by two students in 1886. As the director was, in 1883, a member of the Maryland Oyster Commission, the outfit of the laboratory was that year moved from Beaufort into the Chesapeake Bay, and we occupied a building which we rented from the Normal School at Hampton, Va. As Hampton proved to be a very unfavorable place for our work we returned to Beaufort the next year, and we have accordingly spent five seasons at Beaufort.

During the season of 1886 the zoological students of the University were stationed at three widely separated points of the seacoast. A party of seven under my direction visited the Bahama Islands, two were at Beaufort, and one occupied the University table at the station of the U. S. Fish Commission at Woods Hole.

The party which visited the Bahamas consisted of seven persons, and our expedition occupied two months, about half of this being consumed by the journey.

The season which is most suitable for our work ends in July, and we had hoped to reach the Islands in time for ten or twelve weeks of work there, but the difficulty which I experienced in my attempts to obtain a proper vessel delayed us in Baltimore, and as we met with many delays after we started, we were nearly three weeks in reaching our destination.

We stopped at Beaufort to ship our laboratory outfit and furniture, but the vessel, a schooner of 49 tons, was so small that all the available space was needed for our accommodation, and we were forced to leave part of our outfit behind at Beaufort.

We reached our destination, Green Turtle Key, on June 2d, and remained there until July 1st. The fauna proved to be so rich and varied and so easily accessible that we were able to do good work, notwithstanding the shortness of our stay and the very primitive character of our laboratory. This was a small dwelling house which we rented. It was not very well adapted for our purposes, and we occupied as lodgings the rooms which we used as work rooms.

## RECORD OF THE VARIOUS SESSIONS.

For the following brief records of the various sessions of the Chesapeake Zoological Laboratory I am indebted in large part to Prof. E. A. Andrews:

1878: 8 weeks, Ft. Wool, Virginia; 7 members. Brooks studied embryology of Lingula.

1879: June 25—August 8, Crisfield, Maryland; 11 members. Brooks studied the oyster. Three barges served as laboratory and quarters. Swarms of mosquitos led to the abandonment of this locality early in August, and the removal of the laboratory to Ft. Wool, until September 15.

1880: April 23—September 30, Beaufort, North Carolina; 6 members. Laboratory and quarters were in the Gibbs house. A steam launch was bought and the laboratory equipped by means of an appropriation from the University.

1881: May 2—end of August, Beaufort, North Carolina; 12 members. An "Elementary Seaside School" had been announced, with lectures by Brooks and S. F. Clarke; fee for the course, $25.

1882: May 1—end of September, Beaufort, North Carolina; 8 members.

1883: May 1—October 1, Hampton, Virginia. As a member of the Maryland Oyster Commission Brooks was obliged to spend this summer on the Chesapeake. The new machine shop of the Hampton Institute was rented as a laboratory, and a fast sloop was added to the equipment. Wm. Bateson there joined the party to study the development of Balanoglossus.

1884: June 1—September 19, Beaufort, North Carolina; 10 members. The illness of Brooks obliged him to return after a month, leaving the laboratory in charge of H. W. Conn. Bateson, who was again with the party, was also seriously ill.

1885: May 23—September 15, Beaufort, North Carolina; 11 members. Brooks became a licensed pilot to take the steam launch in and out of Beaufort Inlet.

1886: June 2—July 1, Green Turtle Key, Abaco, Bahamas; 7 members. The party left Baltimore, May 1, in a small Bay schooner, chartered by the day, with Brooks as pilot. With head winds, mishaps and a stop at Beaufort to take on laboratory furniture they did not reach their destination until June 2.

1887: March 1—July 1, Nassau, Bahamas; 12 members.

After this session, owing to financial losses on the part of the University, the Chesapeake Zoological Laboratory was temporarily suspended and its outfit dispersed.

1888 and 1889: Brooks, with some of his students, was at Woods Hole, Massachusetts, as naturalist in charge of the U. S. Fish Commission Station.

1891: May 26—September 1, Kingston, Jamaica; 15 members. The Chesapeake Zoological Laboratory was established at Port Henderson, on the harbor opposite Kingston.

1892: A party of three, in charge of Professor Andrews, was located at Alice Town, North Bimini, Bahamas. Brooks did not go.

1893: April 20—July 23, Port Henderson, Jamaica; 7 members. Brooks did not go and Dr. R. P. Bigelow was acting director.

1894: April 7—July 7, Beaufort, North Carolina; 9 members. Brooks was present.

1895: June 6—August 13, Beaufort, North Carolina; 4 members. Doctor Siegerfoos was acting director; Brooks was not present.

1896: April 29—July 30, Port Henderson, Jamaica; 4 members. Dr. F. S. Conant was acting director; Brooks was there for a while.

1897: June-September, Port Antonio, Jamaica; 12 members. Prof. James Ellis Humphrey was acting director. Humphrey died there of yellow fever, August 12; Dr. Franklin Story Conant contracted the fever there, and died on his return to Boston in September.

1898: Beaufort, North Carolina; 6 members. Prof. H. V. Wilson was director. In this and all subsequent years students went, with little or no aid from the University, to the U. S. Fish Commission Station at Beaufort.

1901–1906: Brooks was again at Beaufort in 1901 and 1903, and at the Marine Laboratory of the Carnegie Institution at Dry Tortugas, Florida, in 1905 and 1906.

In twenty years the Chesapeake Zoological Laboratory provided facilities for more than 160 workers, and approximately 200 papers were published as a result of these sessions. In reviewing this enterprise one cannot fail to be impressed with the great results accomplished with small financial outlay. For the purposes which Brooks had in mind the advantages of a laboratory whose equipment could be moved from place to place are most evident, and the need of such laboratories is not yet past. May the Chesapeake Zoological Laboratory, or some other worthy successor, continue this work, so well begun by Brooks!

On these various expeditions Doctor Brooks was interested not merely in zoology, but also in botany and geology, and in the customs, characters, and histories of the people among whom he was living. He took keen interest while in the Bahamas in following the route of Columbus from island to island. He advocated the establishment of a Columbus Biological Station in memory of the great discoverer. He was particularly interested in the Indians found by Columbus on these islands, and he wrote a very interesting popular account of them, and prepared a monograph on their physical anthropology based on a study of a collection of their skulls. His love of the artistic was shown in his vivid pen picture of "Life on a Coral Island" and "Aspects of Nature in the West Indies." The following letter, written to his brother while on his last scientific expedition, describes in his vivid manner a trip which he made into the Everglades:

THE JEFFERSON,
KEY WEST, FLORIDA, March 21, 1906.

DEAR CHARLES: I am in the "hottest place in the U. S." in an overcoat and my thickest underclothing. I am to get off to the Dry Tortugas tomorrow, on an excursion of army officers, after having been ten days on the journey. It has been a pleasant and profitable journey on the whole, but the delays have been very tiresome.

Among other side excursions I have been where very few white men have been—into the Everglades—which I found most interesting and very different from what our geographies lead us to expect. The whole interior of southern Florida is a great lake of pure spring water, covered with wild rice and reeds, and with a hard bottom, with no mud. It is surrounded by a rim of limestone about 30 feet above the level of the lower land, and it overflows in rivers wherever the rim is low. We went up a river, very deep and rapid, for about twenty miles, to the rapids, and we got up the rapids by towing on the overhanging branches to the top, where the big river at once became lost in the great shallow lake. We picked out a tree on a little island about five miles away, and pushed through the tall reeds until we reached it. We climbed the tree, and as far as we could see there was nothing but reeds in all directions. After eating our lunch we pushed back through the reeds and struck our river again; but I could not help wondering what would happen to us if we missed the river. The trip down the rapids, about half a mile, was most exciting, and I was nearly torn out of the canoe by some low branches.

On our way back we visited an alligator farm, where they hatch, from stolen eggs, the little alligators that are sold in our northern cities. They also deal in rattlesnakes and owls and hawks. In one pond they had the biggest American crocodile known. He is 19 feet long, big enough to drown a horse, and he is fed on live hogs. It must be very exciting to rob the nests of alligators and crocodiles. If you ever have the opportunity to visit southern Florida you should do so.

Miami is the prettiest tropical town I have ever seen and well worth a visit.

Yours affectionately, W. K. Brooks.

## PRINCIPAL PUBLICATIONS.

As a scientific investigator Brooks showed sound judgment, philosophic insight, and breadth of view. His method of work, like his manner of life, was calm and slow. He was not a prolific writer, and of the one hundred and fifty titles, more or less, which appear in his bibliography, not less than thirty are preliminary notes or republications of other papers. Many of these papers are brief notes or abstracts, so that his total number of important contributions does not exceed one hundred. These were distributed over thirty-five years of his active life, so that he did not average more than three such papers a year. He did practically no research work on vertebrates, and his work on invertebrates was confined almost exclusively to five groups, viz.: pelagic tunicates, mollusks, Molluscoida, higher

Crustacea, and Hydromedusæ. Altogether he published seventeen papers on tunicates, twenty-six on mollusks (fourteen of these on the oyster), three on Molluscoida, fifteen on decapod Crustacea, and sixteen on Hydromedusæ. In addition to these he published five or six general works and about sixty theoretical and popular articles, reviews, etc.

All of his papers, even those which deal with the most detailed and technical subjects, are generally understandable and as little technical as possible. As in his lectures, he took little for granted, began at the beginning, and kept his main topics prominent; moreover, he wrote in an entertaining manner, and his articles contain a certain popular quality while not lacking in scientific accuracy.

His first important paper was on the "Embryology of Salpa," and many of his later works, some of them monumental monographs, were devoted to the anatomy, embryology, and classification of this group of pelagic tunicates. Among these papers the most important are the following: "The development of Salpa," "Origin of the eggs of Salpa," "The anatomy and development of the salpa chain," "Monograph of the genus Salpa," and the "Pelagic Tunicata of the Gulf Stream." His latest work, left unfinished, and for which he had prepared hundreds of beautiful drawings, was a continuation of his great monograph on the genus Salpa. These works on the tunicates are too extensive and complicated to be summarized briefly, but some of his more important conclusions are the following:

1. In his earlier papers Brooks maintained that there is not a regular alternation of generations in the life cycle of salpa, between the solitary individuals and those united into chains, as had been generally held since Chamisso's work on salpa, but that the solitary salpæ are females, and that they produce by budding the chain individuals, which are males. Into each of the chain salpæ, before it is set free, an egg is placed, which comes to maturity in the chain form, and ultimately develops into another solitary individual, thus completing the life cycle. In his later works, as Professor Metcalf has pointed out in a letter to the writer, Doctor Brooks departed in several respects from this early conception. He showed very clearly that the solitary salpa is an immature sexual form, which passes its

germinal cells into the chain individuals, where they reach maturity. Since these germinal cells give rise to both ova and spermatozoa, both solitary and chain forms may be considered potentially bisexual, though the solitary forms never contain mature germ cells.

2. In the formation of the salpa chain a stolon, or stalk, which grows out from the solitary salpa is constricted at intervals, thus giving rise to the members of the chain. The stolon is bilaterally symmetrical, its planes of symmetry coinciding with those of the solitary salpa which bears it, and, at first, the planes of symmetry of every member of the chain coincide with those of the stolon and of the solitary salpa. Very soon, however, a twisting of the chain occurs which leads to the formation of a double row of salpæ, each row with the dorsal surfaces of its members turned outwards, while the ventral surfaces of the two rows are turned toward one another, and the right sides of one row and the left sides of the other are turned toward the base of the stolon.

3. The salpa embryo, which develops from the fertilized egg into the solitary salpa, "is blocked out in follicle cells which form an outline or model of the general features of the embryo. While this process is going on the development of the blastomeres is retarded, so that they are carried into their final positions in the embryo while still in a very rudimentary condition. Finally, when they have reached the places which they are to occupy, they undergo rapid multiplication and growth and build up the tissues of the body directly, while the scaffolding of follicle cells is torn down and used up as food for the true embryonic cells."

4. The salpa embryo is connected by a placenta with one of the members of the chain, and is nourished by placenta cells which migrate from the placenta into the embryo. The placenta is thus an organ which nourishes the embryo, not by the transfusion of blood, but by means of giant cells which in the placenta receive nourishment from the blood of the parent, and then migrate into the embryo, there to break down and supply food to the embryo.

But Brooks' work on salpa is not merely a description of the anatomy, embryology, and classification of these interesting tunicates, for it deals in original and philosophical manner with such problems as the origin of chordates, the origin of pelagic animals, the discovery of the ocean bottom, and the effects of this upon the evolution of life.

Another major line of his work was on the anatomy and embryology of the Mollusca. One of his first papers was on "An organ of special sense in the lamellibranchiate genus Yoldia," this sense organ being a long retractile tentacle, half way between the siphon and the lower edge of the mantle on the right side. This paper was soon followed by one on "The embryology of the fresh-water mussels," in which the entire development of *Anodonta implicata* is described in brief outlines, and the conclusion is reached that the larva, or glochidium, is a specially modified stage, adapted to a special purpose, and having no bearing on the question of the origin of the group. Both of these papers are brief abstracts of three pages each, and they were read at the meetings of the American Association for the Advancement of Science in 1874 and 1875. In a paper "On the affinities of the Mollusca and Molluscoida" (1876) he concluded that Brachiopoda have been derived from Vermes, Polyzoa from Brachiopoda, and the Molluscan Veliger (the prototype of the Mollusca) from Polyzoa. The Lamellibranchiata he held to be a side branch, and not ancestral to the group of mollusks as a whole. Later (1879), in his paper on "The development of Lingula and the systematic position of the Brachiopoda," he held that the Rotifera, Polyzoa, and Veliger were three branches which early diverged from the vermian stem. The Brachiopoda he held to be the most highly specialized members of the polyzoan branch, the Mollusca the most highly specialized of the Veliger branch. For these three branches he proposed the name Trochifera.

In his "Observations upon the early stages in the development of the fresh-water pulmonates" (1879) he observed the rhythmical nature of the process of cleavage, the formation of the ectoderm from the clear cells at the animal pole of the egg, the formation of the endoderm from the macromeres at the vegetative pole, and the lack of a continuous mesodermal layer in the embryo. He devoted particular attention to the fate of the blastopore and the origin of the digestive tract; but since his observations were made exclusively on living material, he fell into several errors, mistaking the shell gland for the mouth, which he maintained appeared opposite the original position of the blastopore, and concluding that the macromeres fuse together, and afterwards bud out cells which form the alimentary canal. In the main the same remarks apply to his "Preliminary observations on the development of the prosobranchiate gasteropods," which appeared in the same year (1879). In this paper, and in a subsequent one on the "Acquisition and loss of a food yolk in molluscan eggs," he devoted much attention to what is now known as the yolk lobe, or polar lobe, which he regarded as a "food yolk." This he believed to be in process of being lost in some cases, as, *e. g.*, the oyster, while it was being acquired in others. It is needless to say that this explanation of this problematical yolk lobe is no longer found to be satisfactory. In a brief paper on the "Development of the digestive tract in molluscs" (1879) he reiterates his mistaken view that in gasteropods and lamellibranchs the blastopore is converted into the shell gland, and that the mouth forms at the opposite side of the embryo. With the exception of a single paper, published in collaboration with one of his students in the last year of his life, this list comprises all of his publications on the gasteropods. The paper just mentioned is entitled "The origin of the lung in Ampullaria" (1908), and is based upon the study of material which he obtained on his trip into the Everglades in 1906 (see p. 53). In brief, the conclusion of this paper is that the lung of this prosobranch has no ancestral connection with the lungs of pulmonates. "The gills, the lung, and the osphradium of Ampullaria arise simultaneously, or nearly so, and they must be regarded as a series of homologous organs specialized among themselves in different directions."

During the second session of the Chesapeake Zoological Laboratory material was collected for a study of the later stages in the development of the squid, *Loligo pealii*, which resulted in the publication of two papers, one "The development of the squid," the other "The homology of the cephalopod siphon and arms." The most important conclusions of these papers are: (1) That the embryonic record of the Cephalopoda "has been simplified to a degree which is without parallel in the animal kingdom, and it is hardly too much to say that the ontogenetic process furnishes us with no knowledge whatever of the phylogeny of the group;" (2) that the yolk sac of the cephalopod embryo is the homologue of the gasteropod foot; (3) "that if the epipodal folds of the gasteropod are regarded as homologous with the cephalopod siphon, the arms of the cephalopod must be regarded as independently acquired structures; whereas if we regard the arms as modifications of the epipodal folds, we must consider the four siphon folds as independently acquired structures;" and (4) "the common ancestor of the gasteropods and cephalopods must have been an unspecialized form, and we cannot expect any valuable results to follow from the attempt to compare any part of the body of a cephalopod with structures which, like the epipodal folds, are not common to the Gasteropoda, but somewhat exceptional."

All his other publications on the Mollusca, fourteen in number, deal with the development and propagation of the oyster. In 1878, during the first session of the Chesapeake Zoological Laboratory, he attempted to find young oysters in the gills of the female, as had been described in the case of the European oyster, but without success. In May, 1879, he went to Crisfield, Maryland, the center of the oyster industry on the Chesapeake, and settled down to study the problem of the development of the oyster. "On Monday, the 21st," he says, "I opened a dozen fresh oysters, and found three females, with their ovaries filled with ripe ova, and one male, with ripe spermatozoa. I mixed the contents of the reproductive organs of these four oysters, and within two hours after the commencement of my first experiment I learned by the microscope that the attempt at artificial fertilization was successful, and that nearly all of my eggs had started on their long path toward the adult form. . . . I have accumulated enough evidence to show, beyond the possibility of doubt, that so far as the oysters of the Chesapeake Bay, during the summer of 1879, are concerned, the eggs are fertilized outside the body of the parent, and that during the period which the European oyster passes inside the mantle cavity of its parent, the young of our oyster swim at large in the open ocean."

This was the beginning of his many publications and his years of labor on the development and propagation of the oyster. His first paper on "The development of the American oyster" was very favorably received, and was republished in whole or in part in many American and foreign journals. In recognition of the importance of this work, he was awarded a medal by the Société d'Acclimatation of Paris. In 1882 the General Assembly of Maryland established a commission to consider ways and means to "Perpetuate the oyster beds of the Chesapeake," and Doctor Brooks was appointed chairman of this commission by the governor. The university released him from active duties, in order that he might devote his entire time for eighteen months to the study of the economic aspects of the oyster problem. A laboratory was established at Hampton, Virginia, where experiments were carried out on the propagation of oysters, and extensive surveys of oyster beds were made. The report of this work was published in 1884, in a quarto of 183 pages, 7 maps, and 13 plates. The legislature paid little attention to the recommendations of this report, and Doctor Brooks undertook by public lectures and newspaper articles to arouse public interest in the subject. To this end he published in 1891 a popular work on this subject, entitled "The Oyster," which was republished in a second edition in 1905. His absorption in this work was so complete that he talked oysters in season and out of season. The story is current that at a university reception a society woman attempted to engage him in small talk; he listened mutely for a while, and then was heard to say suddenly, and with animation, "Madam, the Maryland oyster is being exterminated."

Finally, in 1906, the legislature of Maryland passed a law for the protection and propagation of oysters along substantially the lines advocated by Doctor Brooks, and the satisfaction which he felt in this happy culmination of his long campaign was very great.

A third line of work to which he devoted much attention was the embryology and larval history of the higher Crustacea,* and altogether about fifteen papers dealing with these subjects were published during a period of fifteen years, from 1879 to 1892, his first contribution on the larval stages of *Squilla empusa* representing some of the "Scientific Results of the Chesapeake Zoological Laboratory" for 1878. At Beaufort, in 1880, his interest in this subject deepened, for he saw in the structure and metamorphosis of these animals a means of attacking several larger problems, such as the laws of larval development, the analysis of secondary adaptations, and the meaning of metamerism in both lower and higher animals.

The works by which Professor Brooks will be best known to all future students of crustacean zoology are undoubtedly his large monograph on "Lucifer: a study in morphology," published in the Philosophical Transactions of the Royal Society of London for 1882, and his "Report on the Stomatopoda," which appeared as part of the sixteenth volume of the Scientific Results of the Challenger Expedition in 1886. Not only did he discover that the shrimp, Lucifer, emerged from the egg as a true Nauplius, but, what was even more novel, that the egg itself underwent a total and regular segmentation, and gave rise to a gastrula of the invaginate type. After tracing the metamorphosis through nine distinct stages, and making exhaustive comparisons, he concludes that the highly peculiar segmentation and gastrulation are secondary, but that the three-jointed Nauplius represents a true ancestral form, "and nothing but the supposed necessity of believing that the primitive Crustacea had a large number of somites and appendages opposes this view." He shows that the serial and bilateral homology, so evident in the Crustacea, cannot be explained by supposing that the ancestors of the Crustacea represented a community of independent parts. In his Report on the Stomatopoda he considers this subject again, and concludes that serial homology may be due "to heredity from the same part of the developing egg, rather than from a remote ancestor." The report on the Stomatopoda is distinguished by the great ingenuity and mastery shown in classifying all of the known larvæ of this sub-order and in tracing them to their proper genera, for he had no living material to work with, excepting the two species—*Squilla empusa* and *Lysiosquilla excavatrix*—which he had studied from the southern coast of the United States.

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*For assistance in preparing this abstract of Brooks' work on the Crustacea, the writer is indebted to Prof. F. H. Herrick.

During the period from 1880 to 1883, Professor Brooks undoubtedly contemplated the preparation of a work on the higher Crustacea, of greater scope than anything which he later produced, and this was only partially fulfilled in the publication, in collaboration with F. H. Herrick, of "The embryology and metamorphosis of the Macrura," in the Memoirs of the National Academy of Sciences for 1892. Moreover, it should not be overlooked that one of his most notable papers, in which he described how a Stomatopod—*Gonodactylus chiragra*—was reared, for the first time, from the egg, and in which he traced all its successive stages in the living state, appeared as Chapter III of the latter work.

Another group of animals to which Professor Brooks devoted a large amount of attention is that of the Hydromedusæ. In the study and drawing of these beautiful and delicate forms he combined the enthusiasm of the naturalist and that of the artist. From 1880 to 1886 he published seven papers on the Medusæ, chiefly of the Beaufort region, culminating in his monograph on "The life-history of the Hydro-medusæ: A discussion of the origin of the Medusæ and of the significance of metagenesis" (Memoirs Boston Society Nat. Hist., Vol. 3. 67 pp., 8 plates). This work contains an account of his observations on the life-history of a Narcomedusa, a Trachomedusa, an Anthomedusa, and a Leptomedusa, the four species selected for study being "among the most abundant and characteristic of our Southern coast, yet none of them have been well studied." This is one of the most beautiful, complete, and satisfactory papers which Doctor Brooks wrote; the observations are beautifully recorded, the evidences from his own work and that of others are completely marshalled, and his conclusions give the satisfaction which comes from a broad outlook, an intimate knowledge and a logical presentation of a great subject. In brief, his conclusion as to the origin of the Medusæ and the significance of metagenesis are these: (1) The remote ancestor of the Hydromedusæ was a solitary swimming hydra, or actinula, with no medusa stage, but probably with power to multiply by budding; (2) this became more highly organized, better fitted for swimming life, until it was converted into a medusa, with swimming bell and sense organs, developing directly from the egg, but exhibiting during growth the stages through which the race had passed; (3) after this the larva derived some advantage in becoming attached, either as a parasite or semiparasite, and in this condition it budded off other larvæ, all of which became medusæ; (4) the sessile life of the larva was so advantageous that it was perpetuated by natural selection and the primary larva lost its tendency to become a medusa, and remained a sessile hydra, budding off larvæ which became medusæ; (5) the primary larva acquired power to produce other larvæ, which remained permanently in the hydra state; and (6) finally, the communities thus formed became polymorphic by division of labor, and the sessile habit became so advantageous that the free medusæ became degraded into medusa buds on the bodies of the sessile hydras, or on the blastostyles. Following this monograph, he published six shorter papers on Hydromedusæ, the last appearing only one year before his death. A monograph on American jelly fishes, which he had worked upon for many years, was never completed, though many of the drawings and descriptions were used in some of the other papers named.

He wrote but one text-book, his "Handbook of Invertebrate Zoology," 1882, but this was so excellent that it has been a model for many subsequent books on that subject, and it is probable that if it had been handled by a larger publishing house its success would have been much greater. He was also the author of many scientific articles of a popular sort, in which kind of writing he showed unusual ability. He was inclined to look upon various human problems, such as the education and political position of woman, from the standpoint of zoology, and his popular discussions of the possible improvement of the human race, of instinct and intelligence, of heredity and variation, etc., were both novel and suggestive.

His chief interest was always on the philosophical side of biology, and into this he put a large part of his life work.

Even the special researches, some of which have been named above, were permeated by philosophical inquiry, and most of his books and later contributions were devoted to the deeper philosophical meanings of vital phenomena.

As a boy he had read the works of Darwin, and had been immensely impressed by them, and to the last he yielded to no one in his admiration and reverence for that great master. Probably no other disciple of Darwin was more thoroughly acquainted with his works, and very frequently when criticisms of Darwinism appeared he would point out the fact that the critic did not understand what Darwinism is, or that Darwin had already met and answered the objection raised.

One of his earliest papers, entitled "A provisional hypothesis of pangenesis," which he read before the American Association for the Advancement of Science in 1876, contained the germ of many of his later theories and speculations. This germ is the hypothesis that, whereas fully established peculiarities are transmitted by asexual reproduction as well as by the ovum, new characteristics are transmitted only through gemmules, which are stored in the reproductive glands of the male, and are transmitted to the egg in fertilization. Gemmules from the body of the female may pass into the ova, but there is here no organ for the aggregation and transmission of them. "The male element is thus the originating, the female the perpetuating factor in the reproductive process. The female is conservative, the male progressive."

This speculation, which he sought to support by many observations, became the basis of a volume of 336 pages, entitled "The law of heredity," which he published in 1883. This volume, however, contained much of value besides the speculation named. In some respects it anticipated the Germ-plasm theory of Weismann and the Mutation theory of De Vries, and it won the highest commendation from Huxley and other leaders in biology. Like many other profound thinkers on the subject of heredity, he recognized that no hypothesis of epigenesis offers a satisfactory explanation of heredity, and that there is no escape from some form of the evolution hypothesis. The form which he adopts is Darwin's hypothesis of pangenesis, with the modification suggested above. He points out that it is not necessary to assume that the germ is as complicated as the adult, since under certain conditions the descendants of a single cell may become modified in several divergent directions. He maintains that Darwin's hypothesis may be so simplified that the gemmules may be few in number, simple in their properties, and not infinitely small. Nevertheless, this theory requires us to believe that the egg of one of the higher animals is complex beyond our powers of conception. It is interesting to note that he discusses (p. 131) those cases in which a hybrid resembles one parent or the other, but not both (what we now know as Mendelian inheritance), and he suggests a possible explanation by means of his hypothesis of pangenesis. In similar manner he discusses saltatory evolution (pp. 157, 296), and agrees with Huxley, Galton, and Mivart that nature does make considerable jumps (mutations), especially in the case of domesticated animals and cultivated plants. As instances of this kind he cites the sudden appearance of spike-horned bucks in the species *Cervus virginianus,* the ancon ram, the japanned peacock, and several similar cases among plants, and he "points out that our view of the cause of variation implies that any particular change should in itself be a fruitful source of still greater modifications, so that as soon as a tendency to vary becomes established it will continue to increase until an equilibrium is again established by the natural selection of those modifications which are adapted to the environment."

With regard to the determination of sex, he concludes that "sex is not determined by any constant law; that in certain animals and plants the sex is determined by certain conditions, while in other groups it is determined by quite different conditions" (p. 317). These are only a few of the subjects of present-day interest which are discussed in this book, and which he attempts to explain by his modified hypothesis of pangenesis, and although this hypothesis has no defenders at present, the book is still stimulating and suggestive.

It is interesting, and to many of his followers saddening, to see how far Brooks wandered in later life from the study of the physical phenomena of heredity and variation into metaphysical speculation. In two papers written in the last years of his life, one of them entitled "Heredity and variation, logical and biological" (1906) and the other his address before the Seventh International Zoological Congress in 1907, entitled "Are heredity and variation facts?" he concludes that these terms "represent only imperfect mental concepts, and not facts, and that neither heredity, nor variation nor species can reside in germ cells, nor in chromatin, nor in gemmules. The gradual disappearance of attempts to invent evolutionary hypotheses to account for individual development or ontogeny, and the return to a more epigenetic standpoint . . . seems to me a notable reformation. Ancestral development is as epigenetic as individual development. The being of an individual is not in itself, but in reciprocal interrelations between it and its environment. If these things are true, is it not time to have done once for all with the pre-Darwinian metaphysical notion of species as something which resides in germ cells and is handed down by a substance of heredity?"

This brings us to a consideration of his philosophical and metaphysical writings to which the last ten years of his life were devoted almost exclusively. The publications of this period include some eighteen or twenty papers on philosophical subjects, culminating in the book into which he put the best efforts of his life, and by which he hoped to be longest remembered, viz.: "The foundations of zoology" (1899). This book consists of a series of lectures which were originally delivered at Columbia University, and were published in the Biological Series of that institution. It deals with many subjects fundamental not only to zoology, but to science and philosophy in general. The keynote of this book is found in the following extracts from the introductory lecture: "I shall try to show that life is response to the order of nature—in fact, this thesis is the text of most of the lectures; but if it be admitted, it follows that biology is the study of response, and the study of that order of nature to which response is made is as well within its province as the study of the living organism which responds." Among such responses to the order of nature are various forms of adaptation, correlation, instinct, intelligence, volition, and responsibility, and the question arises as to whether such responses are mechanical. "I am myself unable to discover, in the present status of biology, any demonstration of error in the assertion that life is different from matter and motion," but "I cannot find any contradiction between anything we find in our nature and the ultimate reduction of all nature, including all the phenomena of life and of mind, to mechanical principles; for most students of the principles of science agree that natural knowledge is no more than the discovery of the order of nature. . . . Order is no explanation, but a thing to be explained." "It is a hard thing," says Berkeley, "to suppose that right deductions from true principles should ever end in consequences which cannot be maintained." To which Brooks responds: "In my opinion there is nothing in the prevalence of mechanical conceptions of life and mind, or in the unlimited extension of these conceptions, to show that this hard thing to suppose is true."

It is as impossible to summarize this book as it would be to summarize the Book of Proverbs, or the Meditations of Marcus Aurelius. It is, indeed, a compilation of many meditations which appear to have been written down at many different times, and afterwards joined together with more or less care. The result is a book which contains more pithy, quotable sentences than can be found in any other book dealing with biology with which I am acquainted, but at the same time it is a book which is difficult to analyze, and in places difficult to understand. The titles of the chapters will, in a general way, give the trend of the book; these are: "Huxley and the problem of the naturalist," "Nature and nurture," "Lamarck," "Migration in its bearing on Lamarckism," "Zoology and the philosophy of evolution," "A note on the views of Galton and Weismann on inheritance," "Galton and the statistical study of inheritance," "Darwin and the Origin of Species," "Natural selection and the antiquity of life," "Natural selection and natural theology," "Paley and the argument from contrivance," "The mechanism of nature," "Louis Agassiz and George Berkeley." In the course of these lectures very many important facts and observations on the topics suggested are introduced, and the book is of value from this more usual standpoint of science, but attention is chiefly directed to the underlying philosophical significance of these phenomena. On the whole his chief points of view may be summarized in his oft-quoted remark of Aristotle, that the "essence of a living thing is not what it is made of nor what it does, but why it does it," or, as he expresses it elsewhere, "the essence of a living thing is not protoplasm, but purpose;" and in the further statements which he draws from Berkeley, that "nature is a language," that "phenomena are appearances," and that "natural laws are not arbitrary nor necessary, but natural, *i. e.*, neither less nor more than one who has the data has every reason to expect." His system of philosophy was profoundly influenced by the writings of George Berkeley; his language resembles in its force and beauty the essays of Huxley, but his application of these to the foundations of science is his own.

On his fiftieth birthday, March 25, 1898, his former students united in presenting to him an oil portrait of himself (see page 71), together with a congratulatory address, and at the end of his book on the "Foundations of Zoology" he added on this date the following note:

> For you who have, at this time, for my encouragement, called yourselves my students, I have written this book which has been my own so long that I should part with it with regret, did I not hope that, as you study the great works to which I have directed you, you may still call me teacher. If you are indeed my students, you are not afraid of hard work, so in this day of light literature, when even learning must be made easy, you must be my readers, and you must do double duty; for I take the liberty of a teacher with his pupils, and ask that, after you have read the book, you will some day read it again; since I hope that what may seem obscure, may, on review, be found consistent and intelligible.

Much that he has written still seems to me obscure, although I have read it more than once, but I bear in mind his parting request, and in the meantime profit by that which I do understand, and am charmed by the classical and almost poetical diction in which it is written. Whatever one may be inclined to say of his conclusions and theories, it cannot be denied that in an age when biological investigators have been content with discovering phenomena, he attempted to go back of phenomena to their real meaning and significance and to point out the relationship of these newly-discovered phenomena to the great current of philosophy which has flowed down to us from the remote past.

In his review of this book, under the caption "A sage in science," David Starr Jordan said:

> Brooks' lectures on the Foundations of Biology constitute a book that will live as a permanent addition to the common sense of science. It belongs to literature as well as to science. It belongs to philosophy as much as to either, for it is full of that fundamental wisdom about realities which alone is worthy of the name of philosophy. Writers of literature have been divided into those with quotable sentences, such as Emerson and Thoreau, and those whose style runs along without break in the elucidation of matter in hand, as Hawthorne and Irving. To the former class Brooks certainly belongs. His lectures are full of nuggets of wisdom, products of deep thought as well as of careful observation. There is not an idea fundamental to biology that is not touched and made luminous by some of these sagacious paragraphs. Whether it be to show the significance of some unappreciated fact, or to illustrate the true meaning of some complex argument, or to brush away the fine-spun rubbish of theory, the hand of the master is seen in every line. . . . The stones which Doctor Brooks has chosen as "Foundations of Zoology" will remain for centuries, most of them as long as human wisdom shall endure. The volume is a permanent contribution to human knowledge, the worthy crown of a life of wise thought as well as of hard work and patient investigation. The biologists of America have long since recognized Doctor Brooks as a master, and this volume, the modern and scientific sequel to Agassiz's "Essay on Classification," places him in the line of succession from the great interpreter of nature, whose pupil and friend he was.

## HONORS, DEGREES, OFFICIAL POSITIONS.

His abilities received early and generous recognition. Apart from his university advancement he received many honors. The honorary degree of LL. D. was conferred upon him by Williams College in 1893, by Hobart College in 1899, and by the University of Pennsylvania at the Franklin Bicentenary in 1906. In 1884, at the age of thirty-six, he was made a member of the National Academy of Sciences. He was chosen a member of the American Philosophical Society in 1886, and a Councillor of the Society in 1906; an Associate Fellow of the American Academy of Arts and Sciences in 1892; resident member of the Boston Society of Natural History in 1875, and corresponding member in 1877; corresponding member of the Academy of Natural Sciences of Philadelphia in 1887; honorary member of the New York Academy of Sciences in 1898. He was also a member of the American Society of Zoologists, the New York Geographical Society, the Society of American Wars. He was a fellow of the American Association for the Advancement of Science, and of the Royal Microscopical Society.

As a result of his investigations on the development of the oyster, he was appointed by the governor of Maryland to be chairman of the Oyster Commission of that State; and he was also made Member Protector, Classe Peche et Pissiculture d'Exposition universelle d'Anvers; he also received the medal of the Société d'Acclimatation of Paris for his oyster work. A Challenger medal was given him for his work on the Challenger Reports; and he received a medal at the St. Louis Exposition of 1904, where he gave one of the principal addresses. He was Lowell Lecturer in Boston in 1901; one of the speakers at the American Museum of Natural History on the occasion of the unveiling of busts of American men of science during Convocation Week, 1906; and he gave one of the principal addresses at the Seventh International Zoological Congress in Boston, in 1907.

For nearly twenty years he was a trustee of the Marine Biological Laboratory at Woods Hole, Massachusetts; and in 1888 he was Scientific Director of the U. S. Fish Commission Station at Woods Hole. He was editor of the Results of the Chesapeake Zoological Laboratory; co-editor, with Professor Martin, of the Studies from the Biological Laboratory of the Johns Hopkins University; editor of the Memoirs from the Biological Laboratory, and a member of the board of editors of the Journal of Experimental Zoology.

All of these honors he prized highly, though modestly, and he rarely mentioned them except in facetious vein. It was characteristic of him, however, that he not infrequently mentioned with pride the fact that he held a U. S. Inspector's Certificate, licensing him as a pilot.

## PERSONALITY.

Professor Brooks was a man of strongly marked individuality. In personal appearance he was short and stout, with straight dark brown hair and heavy dark brown moustache and eyebrows. While in Cambridge, and during the earlier years of his residence in Baltimore, he wore a full bushy beard. He sometimes allowed his hair to grow long, apparently because he disliked to take the time to have it cut. He used to say jocosely that he envied the man who did not need to have his hair cut, and who never wore a collar or necktie. He was generally careless, or rather thoughtless, of dress, and mere conventionalities counted for little with him. His best known portrait is the one painted by Thomas C. Corner, and presented to him by some fifty of his former pupils on his fiftieth birthday, March 25, 1898, a photographic copy of which appears on the opposite page. This portrait was afterwards loaned to the Johns Hopkins University, and it now hangs among the portraits of other distinguished professors of the university in McCoy Hall. It represents him in characteristic attitude, sedentary, meditative, careless of dress, and with that peculiar uplift of the eyes which with him usually preceded speech.

He was slow and deliberate in his movements and speech, and undemonstrative in manner. In general he talked little, and in a low tone. When he had occasion to speak more loudly his voice assumed a rather high and piping quality. With him talking meant expressing ideas, not merely passing the time, and if he had no answer ready when a question was asked him he usually gave no answer until he was ready—it might be several days later—when he would answer as naturally as if the question had been asked only a moment before. These characteristics made him appear somewhat unique and picturesque, and gave rise to many charming anecdotes about him which his students and friends relate with merriment, but real affection.

In spite of his quiet reserve he was usually a very companionable man, and his company was sought and prized by his friends. On his part he was fond of his friends and neighbors, though he was often silent and absorbed in thought. At such times he would occasionally interrupt his quiet reflections by some thoughtful and unexpected remark, such as, "The term supernatural is due to a misconception of nature; nature is everything that is."

His humor was quiet but genuine; he enjoyed a good joke, and would sometimes relate humorous stories, but never any of questionable propriety. His laugh was never loud, and his amusement was shown by a quiet chuckle and twinkling eyes. In particular he enjoyed telling of odd and interesting persons whom he had known, and of the amusing behavior of animal pets. For a puppy that destroyed a copy of Shakespeare he professed a high regard, but one that chewed up cheap novels was a worthless rascal.

His love of animals was deep seated, and between him and his pets there was genuine companionship. In particular his great dog "Tige" was his constant companion for many years. This "noble dog," as Prof. William James has called him, was seven-eighths St. Bernard and one-eighth mastiff, and weighed nearly 100 pounds. He lived with his master during his life at Cambridge, and later accompanied him to Baltimore, and many who knew Doctor Brooks in those days remember how nearly inseparable he and his dog were. On one occasion, when Professor Brooks was living in the country near Baltimore, he took an early train to the city, and put "Tige" in the baggage car. Before the train started "Tige" jumped out, and then, missing his master, he raced after the train and kept within sight for two and one-half miles, when he was lost to view; but he appeared at the laboratory several hours later, and quietly laid down at his master's feet. The affection which Brooks had for this dog was very great, and after "Tige's" death he was often mentioned as if he had been a dear human companion.

For another favorite dog which had been lost in transit between Baltimore and North Carolina, Brooks employed a man to make careful search over the entire line of travel, not because the dog was of commercial value, but because of his affection for him. His attitude toward all animals and plants is beautifully expressed in his introductory lecture on the "Foundations of Zoology," p. 17: "As for myself, I try to treat all living things, plants as well as animals, as if they may have some small part of a sensitive life like my own, although I know nothing about the presence or absence of sense in most living things; and am no more prepared to make a negative than a positive statement."

Professor Brooks was interested in the welfare and practical needs of his fellow-men. In 1879 he gave part of an elementary course in biology for the teachers of the Baltimore schools. In 1882 he lectured before the employees of the Baltimore and Ohio Railroad on "Methods of locomotion in animals." He was also instrumental in establishing a public aquarium in Druid Hill Park. But his principal work of a practical character was on oyster and fish culture. By lectures, newspaper articles, and books he sought to arouse public interest in the great possibilities for public good which lay in these "harvests of the seas."

His sense of honor and justice was highly developed and his indignation was aroused when any case of injustice or abuse of power came to his notice. In particular he respected the rights of servants and the poorly educated, and he resented any infringement of these rights. While at Nassau, a merchant of the town tried to compel Doctor Brooks to pay him the wages of a negro servant of the laboratory. Doctor Brooks refused to do this unjust act, as he regarded it, and he resisted all pressure which was brought to bear to compel him to do this, even at the risk of being unable to sail on the steamer on which he had engaged passage. With a sense of obligation, unusual and perhaps exaggerated, he held that the university which employed him was entitled to all that he might earn by outside work; fortunately for him his university recognized no such obligation.

He was occasionally very happy in the use of scriptural language, illustrations, and quotations. He acquired his familiarity with the Bible in his grandfather's family, where it was read daily. His familiarity with the scriptures was often shown in his writings and conversation. On one occasion, in a discussion of Weismann's essay on "Life and Death," in which, as is well known, Weismann claims that death is not a necessary and primary characteristic of living things, but one which has been acquired, one of the students asked whether such a view was not contrary to religious teaching. Professor Brooks at once replied: "As I remember it, St. Paul teaches that death was not an original corollary of life, for he says 'by sin came death.'"

His nature and cast of mind was strongly reverential, and he could be said to be religious in the higher sense, although he long ago ceased to attend church or to take any interest in the doings or affairs of religious bodies. A few years before his death he talked with the writer upon the subject of immortality, and maintained that faith in immortality was in no sense unscientific. His attitude on these things may be inferred from the following extracts from the "Foundations of Zoology":

> If any believe they have evidence of a power outside nature to which both its origin and its maintenance from day to day are due, physical science tells them nothing inconsistent with this belief. If failure to find any sustaining virtue in matter and motion is evidence of an external sustaining power, physical science affords this evidence; but no one who admits this can hope to escape calumny; although it seems clear that the man of science is right, . . . for refusing to admit that he knows the laws of physical nature in any way except as observed order.
>
> Many will, no doubt, receive with incredulity the assertion that the ultimate establishment of mechanical conceptions of life has no bearing, either positively or negatively, upon the validity of such beliefs as the doctrine of immortality, for example. The opinion that life may be deducible from the properties of protoplasm has, by almost universal consent, been held to involve the admission that the destruction of the living organism is, of *necessity*, the annihilation of life. Yet it seems clear that this deduction is utterly baseless and unscientific; . . . if it be admitted that we find in nature no reason why events should occur together except the fact that they do, is it not clear that we can give no reason why life and protoplasm should be associated except the fact that they are? And is it not equally clear that this is no reason why they may not exist separately?

During his first years at the Johns Hopkins University he and other members of the biological department boarded at "Brightside," on the shore of Lake Roland, seven miles from Baltimore. Here he met his future wife, Amelia Katharine Schultz, to whom he was married June 13, 1878. In after years Mrs. Posey, owner of "Brightside," bequeathed this beautiful estate to her favorite niece, Mrs. Brooks. Here Doctor Brooks and his family lived a happy life, with books, greenhouse, garden, and trees; and here Doctor and Mrs. Brooks entertained repeatedly the graduate students of the biological department. All of these students remember Doctor Brooks' devotion to Mrs. Brooks and the children. His interest in the education of his children and his pride in their achievements were so great that he not infrequently spoke of these things to his students, and his complete devotion to Mrs. Brooks was both touching and beautiful. For several years before her death Mrs. Brooks was an invalid, and Professor Brooks frequently spent days and nights at her bedside reading to her and attempting to ease her suffering, and no other work or duty was allowed to interfere with this service of love. Mrs. Brooks was a woman of simple and charming personality, and one of the most delightful memories which zoological students have of their life in Baltimore is of the pleasant evenings spent with Professor and Mrs. Brooks at their home, when biological classics were read and discussed, when the various biological expeditions were talked of, and in lighter vein, when the sayings of the children were told, the animal pets shown, and the home-grown orchids exhibited. No one who experienced it can ever forget the simple and cordial hospitality of Professor and Mrs. Brooks, nor the sense of deep and abiding happiness which these glimpses of their home life gave.

Professor Brooks was a man of wide culture, though his absorption in his work was so great that many knew him only as a naturalist. He read widely, and wrote with much attention to his style. He knew well the world's best literature and art, and in his later years he found that he had a strong liking for music, especially the great compositions of Beethoven, Mozart, Wagner, and Bach.

One of his strongest characteristics was his judicial and philosophical temper. When he was once asked if he did not fear that someone would anticipate him in his great work on Salpa, on which he had worked for many years, he said: "I long since ceased to be troubled by such thoughts, for if another should publish on this or any other subject before I do, his work would probably be better or worse than mine. If it was better, I should be glad to be saved the mortification of having published poorer work; if worse, it would only afford additional material for my paper." His mind was too large for little things, too sane for foolish ones. He was remarkably original and suggestive in his methods of thought, and in his views of scientific, social, and philosophical problems he was as artless and direct as a child. He was critical, yet tolerant; modest, but dignified; loyal to his friends, his university, and his ideals; independent in thought and action, and not easily moved from a position he had once taken. He was kind and gentle; and neither in his publications nor in his relations with students did he ever deal in scorn, irony, nor invective. President Remsen said that he had been called the most lovable man in his faculty.

What is the secret of his remarkable influence over others, which his students and associates recognize? By general consent it is attributed not merely to his greatness as an investigator and teacher, but also to his character as a man. In his life there was nothing either to be concealed or explained. He was "a man in whom there was no guile;" a man of such transparent simplicity and sincerity, of such single-hearted devotion to science, so simple-minded, natural, kind, gentle, pure in thought and deed, that his *life* as well as his *work* has left an indelible impression upon all who knew him.

## SICKNESS, DEATH, AND BURIAL.

A congenital defect of the heart had caused him to lead a less active life physically than do most men, and to this trouble other bodily ills were added as life advanced. He bore all these ills with fortitude and patience, and many of his friends did not know how serious his condition was. Professor Andrews, who was closely associated with him, says:

> In 1908 difficulty in breathing added to his burdens and his machinery was most seriously out of order. He continued to come to his lectures and worked earnestly to complete a final paper on salpa, for which the drawings were finished and which he planned to write out in the summer. This, he said, would probably be his last piece of serious microscopic research, since trouble with his eyes made the employment of immersion lenses too difficult; and his mind was eager to digest the facts of his long experience and the recent work of others. But his strength

was not equal to the task. Sudden attacks confined him to his home, but yet his will brought him back to his laboratory, till one last day, February 12. After preparatory rest, driven by his conscientiousness, he forced himself to attend an oral examination of a candidate for the degree of Ph. D. Then walking to the train that brought him home, he was there overcome by a serious collapse. He was persuaded to go to the hospital and, after most severe attacks there, rallied; but in nine long months that followed he scarcely left his wheel-chair.

When he returned to his home he got such comfort as might be from the advent of spring, the passing of summer and the long lingering of autumn, amidst scenes so familiar and dear. Despite his critical state he was deeply interested in such news as came to him from the University. His last official act was a strong, successful plea for another when his own interests might well have absorbed his attention. His was real friendship growing out of his own wide sympathies.

While having some strength to correct the proofs of papers in press, he felt most keenly his inability to put his last work upon paper, and till this work was done he would not deem it right to retire or seek a pension.

Professor Brooks once told the writer of this memoir that he proposed to retire from his professorship when he had reached the age of sixty, and thereafter devote himself entirely to philosophical and scientific work. He reached the age of sixty in March, 1908, but how different was his realization from his plan. His retirement was not to the scholarly leisure for which he longed, but to pain, weakness, and mortal sickness. For nine months he struggled against a complication of organic heart trouble and kidney disease; he was unable to walk or lie down, but lived in a reclining chair. For a month before his death he was often in a semi-comatose condition, and for the last three or four days was unconscious. The end came at last at sunrise on Thursday, November 12, 1908.

The autopsy revealed chronic diffuse nephritis, arteriosclerosis, congenital malformation of the heart with open septum ventriculorum, cardiac hypertrophy, atrophy of the olfactory lobes, and atrophy of the cerebral cortex. The heart was enormously enlarged, and with the opening in the septum between the two ventricles it is surprising that he lived as long as he did. He had for years expected death at any time, and at forty congratulated himself on having lived so much longer than any one acquainted with his condition could have expected. It is the opinion of experts that the explanation of his living to such a comparatively good old age, was due to the fact that the heart lesion was very well guarded by muscular tissue, so that it did not increase during life. Had it been otherwise, it would have been out of the question for him to have survived so long.

His funeral was held on November 16th, at Towson, Maryland. After preliminary services in Trinity Church, his body was followed by his colleagues, students, and friends to its last resting place "on the brow of a hill overlooking a broad valley, in the cemetery of the county seat of Baltimore county."

A meeting commemorative of Professor Brooks was held at McCoy Hall, Johns Hopkins University, on Sunday afternoon, December 6, 1908. President Remsen presided, and spoke of Doctor Brooks' early connection with the university, and of his career as an investigator, a teacher, a colleague, and a man. Addresses were delivered by Prof. B. L. Gildersleeve, Dr. H. M. Hurd, Prof. W. H. Howell, Prof. E. A. Andrews, and Dr. Caswell Grave. These addresses, together with a letter from Prof. William Hand Browne, and a biographical sketch of Professor Brooks by Doctor Andrews, were published in the Johns Hopkins University Circular for January, 1909.

A memorial dinner, attended by former students and biological associates of Professor Brooks, was held in McCoy Hall, Johns Hopkins University, on the evening of December 31, 1908. About sixty persons were present, and short addresses were made by Profs. S. F. Clarke, of Williams College; E. A. Birge, of the University of Wisconsin; E. B. Wilson and T. H. Morgan, of Columbia University; H. W. Conn, of Wesleyan University; H. H. Donaldson, of the Wistar Institute; C. F. Hodge, of Clark University; F. H. Herrick, of Western Reserve University; M. M. Metcalf, of Oberlin College; J. P. McMurrich, of the University of Toronto; H. V. Wilson, of the University of North Carolina; R. G. Harrison, of Yale University; E. G. Conklin, of Princeton University, and W. H. Howell and E. A. Andrews, of Johns Hopkins University.

At this dinner it was decided to publish a memorial volume to Professor Brooks, to consist in the main of original scientific papers contributed by his pupils. Since Doctor Brooks was one of the editors of the Journal of Experimental Zoology, it was decided to publish this memorial as a volume in that series; and it is now in course of preparation. In what better way may the memory of a great scientist and teacher be honored than by carrying forward the torch which has fallen from his hand?

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NATIONAL ACADEMY OF SCIENCES
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# BIOGRAPHICAL MEMOIR

OF

# THOMAS CHROWDER CHAMBERLIN

1843-1928

BY

ROLLIN THOMAS CHAMBERLIN

PRESENTED TO THE ACADEMY AT THE AUTUMN MEETING, 1932

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## THE ANTECEDENTS

The Chamberlain family has been traced back to the ancient Norman counts of Sankville, knights from which stock took an active part in the conquest of England under William the Conqueror and were repaid for their services with large estates in the counties of Gloucester, Oxford, York, and Warwick. The founder of the family of Chamberlain in England, as an independent branch of the house of Sankville in Normandy, is said by some to have been Richard, "Grand Chamberlain" to King Stephen, who assumed his surname from his office.[1] According to another account, it was the Count of Sankville, chamberlain to King Henry the Second, who gave rise to the name in 1154.

In the early days of the American colonies several members of the Chamberlain family emigrated from England to the new country, among whom was Henry Chamberlain, who came to Hingham, Massachusetts, in 1638 from the parish of Hingham, County Norfolk, England, having crossed the Atlantic in the ship "Diligent," with his wife, his mother, and his two children. He was one of many who, under the leadership of the Rev. Robert Peck, fled from the religious persecution in England at that time. Later this branch of the family was engaged in ship building in New England. One member, Joseph, grandfather of Thomas Chrowder Chamberlin, went to North Carolina in the interest of the family's business, married Sarah Cartwright, and settled there. Ten of their children lived to maturity and evidently prospered, for the Chamberlains are said to have become the richest and most prominent family of Camden County, North Carolina. The second son, John, became convinced early that the system of slavery, which played an important part in the plantation life of the time, was an evil one, and because of his strong feeling on the subject he left the slave-holding region for the newer country farther west. He traveled through Tennessee to Palestine, a small settlement on the Wabash River in Illinois. It was here that he met and married Cecilia Gill, a girl of Scotch descent who was born at Lexington in the Blue Grass region of Kentucky. Shortly after their marriage they moved about sixty miles westward. There, on the crest of the Shelbyville terminal moraine, a few miles southwest of the site of the present city of Mattoon, were born the three oldest boys—William Fletcher, John Nelson, and Thomas Chrowder. In this geologic setting, prophetic of his later interests, Thomas appeared on September 25, 1843.

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[1] During the succeeding centuries over twenty variations in the spelling of the name came to be recognized in England.

## THE BEGINNINGS

When Thomas was about three years old, the family started on a long journey to the wheat country of Wisconsin, traveling, as was the custom of the time, in two "prairie schooners," and camping many nights on the lonely prairie. Family tradition has it that the boy learned his letters on the way. When they reached Beloit, a small settlement just over the Illinois-Wisconsin state line, they found land to their liking and located near a grove on a ridge about four miles northwest of the village. The ridge-top above the rolling prairie was a stimulating environment for the development of a naturalist, for myriads of the now extinct passenger pigeons and countless other birds, each year migrated northward and southward and were set forth sharply on the black stubble left by the fall and spring prairie fires. Often at night wolves came up to the picket fence that surrounded the log cabin and quarreled with the dog till a blast from the old flint-lock shotgun scared them away.

One of Thomas' earliest remembrances was that of his father telling of the "laying of the corner stone," a matter which impressed the boy deeply, though he had not the slightest notion of its meaning. It referred to the founding of Beloit College, in 1847, an institution that had a profound influence on the boy in later years. When he was a small boy of eight a rather prophetic incident occurred. One rainy day when Thomas and his two older brothers were playing together, one of them asked in fun what Thomas was going to do when he grew up. Thomas came back quickly with the reply: "I'm going to school till I can teach the best school in the state," at which the brothers laughed until Thomas became embarrassed. His father caught the answer and said, " Boy, don't you back out. Stick to it!" And Thomas stuck to it.

From the original log cabin the Chamberlin family progressed to a more modern farm house which they built about a mile away. When as a helper to the two older boys, Tommy quarried rock from an outcrop of Trenton limestone he debated with his brothers how the great "snakes" (portions of orthoceratites) could have gotten into the layers of rock and turned to stone. It was easy to see how they got down the crevices, but how could they get in between the layers where the boys found them? So, too, in digging sand for mortar, they found clay pebbles that were soft and could be broken with the fingers. They easily decided that these clay masses were young growing stones that had not yet hardened. This was the first school of geology the boy attended, and his only textbook was Nature's own, written a long time before.

In the course of time, two younger sons, Joseph Hanson and James Alexander, appeared in the Chamberlin family circle. The father, by preference a Methodist minister, by necessity a farmer as well, was known as a "circuit rider" because of his practice of riding around to several different meeting places each Sunday to preach. In time, this overtaxed his strength and eventually undermined his health. Though of limited academic education, he was an incisive thinker and reader in theological-philosophical lines, strict in his views, and greatly given to argument on religious subjects. He was regarded as abler than any of his boys and was long remembered locally as a man of exceptionally clear speech and systematic ideas. Thus the sons grew up in an atmosphere of serious and sharp debate in theology and philosophy.

In succession the five Chamberlin boys, Fletcher, Nelson, Thomas, Joseph, and James, entered Beloit College. The curriculum was wholly prescribed, modeled on the classical courses of the colleges of New England, and on that of Yale in particular. In large part the course was Latin, Greek, and mathematics, though containing some history, philosophy, and science. Thomas was most deeply interested in philosophy and mathematics. Geology he faced with the attitude of a skeptic, for it did not at all agree with his theological beliefs. He determined to investigate the subject in order to show that his theology was right and that the geologists were wrong. So thorough were his investigations that, instead of convincing the geologists of their errors, he convinced himself of the truth of their contentions. When, at the end of the term, he went to his professor to find out his standing in the class, the older man turned and, with a twinkle in his eye, said: "Well, Chamberlin, would you like to know who stood next?" With this encouragement, Thomas became even more interested than before in the subject of geology.

On graduating from Beloit College, in 1866, Thomas Chamberlin was engaged as principal of the Delavan (Wisconsin) High School in which he had been preceded by men of more than ordinary ability and success. The situation was, therefore, highly stimulating to his work. He soon came to feel that the course of study was too narrow and barren to give the young men and women what they ought to know as an equipment for life, particularly in respect to the earth, and the heavens, and to the great events of the past. So he introduced a series of lecturettes on elementary phases of geology, astronomy, and other natural sciences, and occasionally on fine afternoons he took his students on field trips to explore the wonders of the out of doors.

In 1867 Thomas married Alma Isabel Wilson of Beloit, whose gentle, cheerful nature was the basis for the happiest home life and who until her death in 1923 was a great inspiration to him. Many of his early notes and manuscripts are in her clear, beautiful penmanship.

Since his equipment for teaching the innovations which he was introducing was very meagre, Thomas felt keenly the need for a broader foundation in natural science. He also foresaw the coming wave of scientific development. In 1868, therefore, he and his young wife went to Ann Arbor for graduate study in science at the University of Michigan, which seemed to offer its learning for the least money. In 1869, after a year spent on a wide range of studies, including some work in geology under Alexander Winchell, young Chamberlin was called to the "settee" of the natural sciences in the State Normal School at Whitewater, Wisconsin. Though his field included all the usual sciences listed, by concentrating his study on one science after another during a period of two or three years, he became qualified to teach all of them to the extent required for his pupils.

It was here at Whitewater, while inspiring eager young minds with an uncommon enthusiasm for the phenomena of Nature, that he first found himself. In 1920, as a mature scientist, he wrote to his old pupil, Professor L. C. Wooster of the Kansas State Normal School, the following brief letter: "I still look back upon the beginning of my work at Whitewater as among the halcyon days of my life. To be sure, it was a stage of small attainments, but it was as full of endeavor to get on and get more that was worth while as any later days, and the fruits were just as sweet, for no fruits are perfect. They are merely pabulum on which to grow."

Of the results let one speak who came shortly after Professor Chamberlin left Whitewater.[2]

"When I first entered the school I found that it had a decided bent toward natural science. All the other departments were overshadowed by the predominance of this. The opinion of the teacher in natural science, even on Latin roots, was more highly esteemed than that of any other teacher in the school. Because of this prevalence of the scientific spirit, many a student received such an impulse toward the natural sciences that it developed into a passion, and gave direction to his future career. There has been a larger number of the earlier graduates of this school who have become teachers of science, or who have given unusual attention to some branch of it, than from any of the other normal schools. I need but mention Professor King of Wisconsin University, Professor Salisbury of Chicago University, Professor Ewing of River Falls Normal School, Professors Culver and Buell of Beloit, Professor Wooster of Kansas, in evidence of this. I have thought that this was due to the fact that Professor T. C. Chamberlin was one of the earliest teachers of natural science in this school and made his department first in the esteem of the students."

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[2] Prof. Lewis H. Clark, '79. Reminiscences of the Faculty. Historical Sketches of the First Quarter-Century of the State Normal School at Whitewater, Wisconsin, 1868-1893, p. 51. Madison, 1893.

## THE GEOLOGICAL SURVEY OF WISCONSIN

In the spring of 1873, Governor C. C. Washburn signed a bill providing for a complete geological survey of Wisconsin and appointed T. A. Lapham chief geologist and Roland D. Irving, T. C. Chamberlin, and Moses Strong assistant geologists. To Chamberlin was assigned the southeast section of the state. The iron deposits lay in the central and northern sections, the lead and zinc deposits in the southwestern corner. The member of the legislature who, under Chamberlin's stimulus, had been most active in procuring the passage of the bill which established the Survey, on learning of the appointments of others to the mineral regions, said pointedly: "Mr. Chamberlin, you are shelved. What is there to be found in southeastern Wisconsin?" In reality, there seemed to be little more than the well-known early Paleozoic beds, covered up deeply with glacial drift. The apparently unpromising area practically forced Chamberlin to become a student of glaciation, and it was his studies in this field that eventually led him into the fundamental problems of geology and cosmogony.

From 1876 to the completion of the Survey in 1882, Chamberlin was chief geologist, instructed by the legislature to perform a task the comprehensiveness and difficulty of which may be gathered from the words of the enactment (Chapter 121 of the Laws of 1876):

"The people of the State of Wisconsin, represented in Senate and Assembly, do enact as follows: Section 1. That in the preparation of his final report, the chief geologist be, and he is hereby, authorized to collate the general geology and the leading facts and principles relating to the material resources of the

State, together with practical suggestions as to the methods of detecting and utilizing the same, so as to constitute the material for a volume suited to the wants of explorers, miners, land owners and manufacturers, who use crude native products, and to the needs of the schools of the State, and the masses of intelligent people who are not familiar with the principles of geology; said volume to be written in clear, plain language, with explanations of technical terms, and to be properly illustrated with maps and diagrams, and to be so arranged as to constitute a key to the more perfect understanding of the whole report."

The Survey, and particularly the chief geologist, had a hard task to perform. At that time the physical difficulties alone of so comprehensive a survey were enormous; the time allotted short; the legislature had to be cultivated for appropriations, and a capable group of collaborators had to be assembled and directed. Then, as always throughout his career, Chamberlin gathered around him able associates, among whom were Irving, Strong, Wright, Pumpelly, Sweet, Brooks, Whitefield, Wight, Wooster, King, Van Hise, and Salisbury. It was a time of great activity for the State Geologist, yet in the midst of these labors he served also part of the time as professor in Beloit College, and gave short courses of lectures on the relations of science and religion to audiences which filled the Second Congregational Church of Beloit.

That the Survey was strikingly successful is evidenced by the four grand volumes, "Geology of Wisconsin," in the last of which to appear (Volume I, 1883) the State Geologist carried out in remarkable fashion the difficult requirements imposed by the legislature. These volumes even today are highly prized by the people of Wisconsin and, as models of pioneer geologic research and of clear unfolding of the geology of a state, still stand without a peer.[3]

Chamberlin's scientific contributions ranged widely through many fields, but none was more characteristic of the man than the unraveling of the origin of the glacial deposits, the lead and zinc ores, and the Silurian coral reefs. Though "the survey in the seventies swept over the Pleistocene formations and those that underlie them at the rate of about 4,000 square miles a year,"[4] Chamberlin's early studies of the Wisconsin Kettle Moraine were so outstanding as to win speedy recognition by geologists. In 1878, he went to Europe to present his results at the International Geological Congress in Paris and to study the workings of existing glaciers in the Alps. Upon returning to Wisconsin, he soon came to recognize that the prominent kettle moraine crossing the state in louped festoons divided an area of later glaciation from that of an earlier one. He thus recognized that the problem was more complex than he had supposed and that it reached beyond the scope of a single state survey.

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[3] C. K. Leith, Chamberlin's Work in Wisconsin. Jour. of Geol., Vol. XXXVII (1929), p. 291.

Soon Chamberlin's Wisconsin glacial studies merged into the broader investigations which he started when he was appointed Chief of the new Glacial Division of the U. S. Geological Survey. Glacial studies at that time were somewhat further advanced in Europe than on this side of the Atlantic, but the penetrating examination of the unsurpassed glacial records left in the Upper Mississippi Valley soon placed American glacial investigations on strong, independent foundations and led to the important later developments.

Who can read the 200 pages in Volume IV, Geology of Wisconsin, upon the lead and zinc ores of the state, without realizing that here is a remarkable piece of work? The technical descriptions are rich in their fullness of significant details, and clear, lucid, and literary in diction, but the competent reader is most deeply impressed by the fertility of Chamberlin in framing and evaluating the possible hypotheses for the origin of the deposits. The "method of the multiple working hypotheses" is already being used. Hypothesis after hypothesis is tested with thoroughness and rejected because of its inconsistency with important facts. The favored view is discussed fully, carrying along several alternative sub-hypotheses, some one of which, or some combination of which, seems likely to loom large in the ultimate explanation when that stage shall be reached. The conclusions have been called daring in conception, and so they may seem, but they were the result of a far-seeing vision guided by rigorous logic and a mastery of the facts and principles involved. They have seemed daring largely because transcending the ordinary.

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[4] T. C. C.: Preface to the "Quaternary Geology of Southeastern Wisconsin," by W. C. Alden, U. S. Geological Survey Professional Paper 106 (1918), p. 13.

Chamberlin believed that the lead and zinc salts were carried to their present position in solution in descending meteoric waters which had obtained them from a more disseminated distribution in the Ordovician strata of the region. A zone of oxidation lay near the land surface. Below was a zone of "sulphuration" in close relation to shales so rich in bituminous matter that a fragment can be ignited with a match. Here occurred precipitation of the sulphides. Referring to the important percolating waters, he wrote: "That from the zone of oxidation carries in the metallic salts in solution while, below, there enter sulphureted waters and the two, mingling, deposit the ore."[5]

That some experts in ore deposits, coming later, attributed these ores to ascending hot solutions, worried him little, for he had great confidence in the essential correctness of his early work and he explained in a decisive way why the later interpretations seemed to him untenable. In fact, he himself had already discussed these alternative possibilities with great pains and rejected them in his original report.

In Volume II the peculiar dome-like structures in the Niagara limestone at Racine, Wauwatosa, Waukesha, and several other places in southeastern Wisconsin were minutely described and boldly interpreted as ancient coral reefs.[6] Fifty years later, Cummings and Shrock paid the following tribute to this truly surprising work: "Wisconsin has the honor of being the State in which the pre-eminent Chamberlin first accurately described ancient reef structures in America. His diagrams and descriptions (1877) leave little to be desired, and he correctly distinguished both the reef and inter-reef lithologic facies and distinct faunas."[7] This remarkable diagnosis was several decades ahead of its time. Many other geologists throughout the whole span of years since 1877 have seen much of these prominent structures in Wisconsin, Illinois, Iowa, and Indiana; but lacking the daring imagination necessary for correctly explaining the various phenomena on exhibition, they have remained either baffled or incredulous of the reef interpretation.

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[5] Geology of Wisconsin, Vol. IV, p. 550.

[6] Geology of Wisconsin, Vol. II (1877), pp. 351-371.

Chamberlin made many more important contributions than that of describing and diagnosing the Niagaran coral reefs, but no single achievement seems more amazing than this early advance into the unknown. The training of the young State Geologist had been limited; he had traveled but little and at that time (1877) had never seen the ocean. Moreover, these quaquaversal structures were to him but minor features in a rapid survey of a large state. Only the true instinct of superior genius could have enabled him in those days to interpret correctly phenomena which have continued to puzzle geologists almost to the present time. Prophetic vision was the most outstanding characteristic of his mind, as was to be shown over and over again in later years.

## ON THE UNITED STATES GEOLOGICAL SURVEY

In 1879, the United States Geological Survey was established with Clarence King as director, but the following year the directorship passed to Major J. W. Powell who reorganized the Survey into divisions. The success of the Wisconsin Survey, and particularly the character of its reports, had so strongly impressed Powell that he appointed Chamberlin to take charge of the glacial division of the Federal Survey. In transmitting this appointment on June 17, 1881, Powell gave the following instructions:

"The terminal moraine that enters the United States on the north border of the Territory of Dakota and stretches thence southward and eastward in sinuous course probably to the Atlantic will be the subject of your investigations for the coming year. You will also study such collateral deposits as may be intimately associated with its history. Your investigation should be devoted principally to that portion lying in the Territory of Dakota and to such other portions as have not hitherto been traced; giving to still other portions the examination that may be necessary to determine the relations of the several parts and the proper delineation of the whole on the map."

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[7] E. R. Cummings and R. R. Shrock: Niagaran Coral Reefs of Indiana and Adjacent States and Their Stratigraphic Relations. Bull. Geol. Soc. Amer., Vol. 39 (1928), pp. 579-620.

Thus commenced Chamberlin's work as geologist in charge of the glacial division of the United States Geological Survey, which continued until 1904 concurrently with many other duties in the later years. Carrying out the original instructions from Major Powell, Chamberlin worked from Montana through to the Atlantic coast. That there was an old glacial drift and a younger glacial drift, which in general did not reach so far south as the deposits of the earlier glaciation, he was quick to recognize, and he made it his task to trace the border of the younger drift across this great stretch of country. Others became associated in this work: J. E. Todd, in Dakota and Iowa; Warren Upham, in Minnesota; L. C. Wooster, in Michigan; and R. D. Salisbury, in New York. Earlier work in Pennsylvania by H. C. Lewis and G. F. Wright; in New Jersey, by G. H. Cook and J. C. Smock; and on Long Island, by W. W. Mather also aided much in the project. But the geologist in charge personally worked out long stretches of the chain, went over other links with his associates, and coordinated the whole into a comprehensive, well-considered report entitled "Preliminary Paper on the Terminal Moraine of the Second Glacial Epoch," which appeared in 1883 in the Third Annual Report of the United States Geological Survey.

Though ever scrupulously careful to give full credit to the work of others, it is apparent that the published report is very largely based on the observations and interpretations of the geologist in charge. Yet so rapidly were these studies completed that the finished report of 107 quarto pages was submitted by the director of the Survey to the Secretary of the Interior as a part of the Third Annual Report on July 1, 1882, scacely a year after the assignment of Chamberlin to the task. The several maps cover the entire glaciated portion of the United States east of Montana, delineating the outer limit of the old drift, the limiting terminal moraine of the young (Wisconsin) ice advance, together with the directions of ice movement within the area of the young drift. Many refinements have since been made in the mapping and we now know that there were four main drift sheets instead of two, but "the importance of this paper was very great at the time of its publication."[8]

The Fifth Annual Report (1883-84) contained one of the classics of geological literature, "The Requisite and Qualifying Conditions of Artesian Wells," by T. C. Chamberlin. Artesian wells had been explained by French and English geologists many years earlier, but there had been no comprehensive analysis of the principles involved to compare with this for practical value. It was one of those publications of broad, fundamental principles and wide application for which the earlier years of the United States Geological Survey were notable and which built up the prestige that the Survey came to enjoy.

The Sixth Annual Report (1884-85) includes a joint paper by T. C. Chamberlin and R. D. Salisbury entitled "The Driftless Area of the Upper Mississippi." Within its 118 pages the reader finds a clear delineation of the characteristic features of the driftless area, compared and contrasted with the dominant features and peculiarities of the adjacent glaciated tracts. There is also an incisive treatment of the residual products of rock weathering characteristic of this area free from glacial scouring. A masterful discussion of the loess and its problems will also impress the reader; but what will strike him most is, no doubt, the thorough-going philosophical handling of the detailed problems, large and small, which combine to make the full story of the driftless area. Many of the conclusions were frankly stated to be tentative, some questions were left open for further development of knowledge, and for some of them the authors later modified their views; but as a study in the methods of scientific investigation where the problems are complex, this report will make stimulating reading for a long time to come.

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[8] W. C. Alden: Thomas Chrowder Chamberlin's Contributions to Glacial Geology. Jour. of Geol., Vol. XXXVII (1929) p. 299.

At that time Baron von Richthofen's eolian hypothesis of the origin of the loess was contending with the more generally accepted theory of aqueous origin. In the Driftless Area report each hypothesis was confronted with the facts presented by the loess of the Mississippi Valley, and the strong points and weaknesses of each were critically discussed. The aqueous hypothesis met a great difficulty in accounting for the widespread waters required by the distribution of the loess. In their thorough canvass of the possibilities, the authors considered ice dams which might have ponded waters over the loess region; and they enlisted the services of R. S. Woodward to consider mathematically the possibility that the attraction of the ice sheets by tilting the water level changed the drainage so as to furnish the requisite conditions for loess deposition in spite of the lowering of sea level by abstraction of water to furnish the ice of the continental glaciers. They considered also the possibility of crustal deformation due to weighting by the ice burden, and other causes. In the end they came very near to, but did not quite reach, the complete interpretation of the loess of this region as glaciofluvial silts swept up by winds from floodplains of streams from the melting ice and deposited widely. This theory, as set forth by the senior author in 1900, has hardly been improved upon by thirty years of subsequent study.

The assigned reasons for the driftless area in this location stand today just as they were outlined in the "Sixth Annual Report." To one familiar with the peculiar situation of the driftless area between tongues from the Labradorean and Keewatin ice sheets and with the well-known "Jardin," in the Talèfre basin of the French Alps near Chamonix, the poetical finishing sentence of the report is singularly full of meaning. "Diverted by highlands, led away by valleys, consumed by wastage where weak, self-perpetuated where strong, the fingers of the mer de glace closed around the ancient Jardin of the Upper Mississippi Valley, but failed to close upon it."

'The Rock-Scorings of the Great Ice Invasions" was a notable contribution which came out in the "Seventh Annual Report" (1888) after its author had become President of the University of Wisconsin. In an exhaustive study of the phenomena of striation, plucking, grooving, fluting, chatter marks, crescentic gouges and polishing, the records left on rock surfaces by glaciers were described and interpreted, and the inferences deducible from them as to the nature of glacier movement and its effects on underlying surfaces were developed in detail. Today, perhaps, we may be inclined to regard these features as of minor importance; certainly they were very simple compared with the profound philosophical studies into which the author was led in his later years. Yet his powers of observation and analysis and his capacity for taking pains are here revealed just as truly in this handling of small problems as in anything which he ever did. The accompanying glacial map of the United States, portraying the area of the earlier drift and that of the later drift, with the directions of striae for the eastern half of the country, records faithfully the state of knowledge in 1886.

The period of Chamberlin's greatest activity on the Survey closed in 1887 when he went to Madison to take up executive work as President of the University of Wisconsin. The heavy administrative burdens at Madison, and later the increasing diversity of interests at Chicago, left much less time for active field work, but by means of frequent conferences he continued to direct the work of the glacial division. He had trained several of his colleagues in these investigations, giving them the working criteria which they carried out with fidelity and painstaking care under his leadership. Thus it is, perhaps, only fair to state that much of the constructive synthetic thought and general interpretations which appeared in the glacial publications of the United States Geological Survey up to his retirement from general charge of the division in 1904, and for several years thereafter, were due directly or indirectly to T. C. Chamberlin.

## PRESIDENT OF THE UNIVERSITY OF WISCONSIN

In the spring of 1885 Chamberlin had been offered tentatively the presidency of the University of Wisconsin, but he preferred to continue in his chosen field of geology. A second approach met with no more favorable response. The Board of Regents of the University, however, continued to press him, urging that the State of Wisconsin had given him his start and that his duty to the state lay in accepting the presidency. This to him was indeed an appeal hard to resist, and he was formally elected to the office by the Board of Regents on June 23, 1886. A full year, however, was granted for completing as much as possible of the Survey work.

When Chamberlin became President of the University of Wisconsin, in the early fall of 1887, it was still essentially a college. President Bascom had been a remarkable teacher and had brought from Williams College much of the spirit and tradition of a New England college. But a new type of educational institution was then coming into prominence with Johns Hopkins and Cornell as conspicuous leaders. The new president was young, vigorous, full of ideas, to a certain extent self-made and unhampered by tradition, and quick to see the best in new developments. The situation at Wisconsin was then favorable for educational advancement. New buildings to take care of the more pressing needs had recently been provided. Various other desirable but less urgent improvements could wait. Promptly and boldly he seized the opportunity to initiate a radical reorganization of the university.

So well has the nature of this reorganization been presented by Pyre in his excellent book on the University of Wisconsin that one can hardly do better than to quote extensively from it:

" 'The University of Wisconsin is in that transitional period in which it is easy to go either backward or forward,' wrote John Bascom, in his farewell *Report* to the Board of Regents. There was no doubt of the direction which President Chamberlin chose to pursue. With clearly defined purpose, he set about advancing the institution to a university basis. More distinctly than any predecessor he understood the university in three dimensions. He saw at once the opportunity to extend it both in area and in depth. More distinctly than any predecessor, also, he grasped at once the triple function of the university, that of undergraduate and professional instruction, that of original investigation combined with graduate teaching, and that of "university extension," or popular dissemination of the essentials of advanced knowledge. Of these, the distinctively university function, he saw, was that of individual research and leadership in original study, and his dominant interest was in the development of the institution in this plane. But before this could be accomplished in any notable degree, the spirit of investigation must be conveyed into the undergraduate courses so that they might lead up naturally, not in information only, but in method, to work of the distinctive university type. In lateral extension of the curriculum, therefore, favor was shown to subjects of study which lent themselves to modern methods of investigation and teaching; or which, as in the technical departments, were most forward in the application of science to industry. Of several departments established at this time, it could be said, and was, that their counterparts had not previously existed in any university. In order to facilitate all of these activities it was desirable that the university should be organized on a more logical and workable plan."[9]

At that time the Agricultural College was an experimental station with an occasional student. The Engineering School had departments, and the last years of the engineering work were separated from the general scientific work of the college. On the other hand, the College of Letters and the College of Arts overlapped. The nominal divisions of the University did not coincide with the actual alignment of interests. Quoting again from Pyre:

"Accordingly an act of legislature was procured in 1889, whereby the old organization was abolished and the University was reconstituted into the four colleges of Letters and Science, of Agriculture, of Engineering, and of Law. All the departments of pure knowledge and investigation, including the physical sciences. were associated together in a single college, with complete autonomy as to its internal affairs; each of the more powerful divisions of professional or applied knowledge was erected into an independent organization with which the central college might have such relations as should seem, at any time, reciprocally advantageous."[10]

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[9] J. F. A. Pyre: Wisconsin (1920) pp. 258-259.

Thus commenced the system of organization now in operation at the State University.

"The development of the special colleges constituted one phase, and an important one, of the transition from college to university. Equally fundamental were the changes wrought in the central College of Letters and Science. Here again the University is indebted to the initiative of President Chamberlin. Had he, in his sympathy with natural science, elected to give the institution a powerful impetus in this direction, it could not have been considered remarkable. Nearly half a million dollars had just been expended by the State for the new group of science buildings and the nucleus of a strong scientific faculty had already been collected. The opportunity for a special development was obvious. Nothing in Chamberlin's administration, therefore, is more noteworthy than the largeness of spirit in which he set about to strengthen the humanities. But he saw with great clearness that, if the humanities were to be maintained in competition with science, they must be reanimated by an infusion of as much of the modern spirit as was compatible with their nature. 'The remarkable advance which the natural sciences have made in recent years as educational factors,' he wrote in his earliest *Report*, 'has been dependent very largely upon the laboratory and field methods which have given them vitality and effectiveness. Parallel methods in other departments of study undoubtedly mark a coming era of vigorous growth and commanding influence.' "[11]

"For the purpose of permitting greater concentration, continuity, and thoroughness in the leading lines of study"[12] the Group System was installed, whereby the first two years of the undergraduate work were devoted to the acquisition of a general education through a basal group of required subjects, to be followed in the junior and senior years by a "major" line of study. The latter was introduced not as a requirement, but as optional. The student was free to follow what was called the Course System, which was substantially what the University had, or he could follow the Group System in which he would concentrate his work more and more in the last two years of the course. The announced purpose of this system was "to introduce university methods, in the modern sense of the term, more largely in the undergraduate college course, and so prepare the way for the better development of graduate work." [13]

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[10] Pyre: op. cit. p. 259.

[11] Pyre: op. cit. pp. 280-281.

[12] Pyre: op. cit. p. 282.

"Then he hoped to concentrate the informational aspects of education, the part of education which consists in accumulating a reasonable amount of handy information that belongs to a college man, by a system of short lecture courses known as Synoptic Lectures. It was a fine idea, and about the only phase of his work that has never been adequately developed. If he had stayed here, he would probably have developed that, but it took a genius and a great deal of energy to develop an idea so novel. The modern form of it appears in numerous orientation and adjustment courses that we see in colleges, none of which looks as attractive in many ways as Chamberlin's original ideas." [14]

"The introduction of the Group System necessarily had two effects. One was that it brought about the introduction of a considerable number of elective studies for the advanced undergraduate students, and the other that it led inevitably to the continuing of this advanced work as graduate study; so that the next thing which Chamberlin did was to begin the formal development of graduate study. He did that in three ways; in the first place, by encouraging the offering of courses; in the second place he established graduate fellowships for the first time in the history of the University; and in the last year of his administration he organized the School of Economics, Political Science, and History, and brought Dr. Richard T. Ely from Johns Hopkins here to head it; and that was very definitely to have graduate study as the primary object. Of course this movement toward graduate work antedated the founding of the University of Chicago, and I do not believe that any university in the Middle West was moving specifically toward graduate study in the way that we were during the early part of Chamberlin's administration." [15]

He found a strong faculty when he came, and he added greatly to it. Very early he called Joseph Jastrow from Johns Hopkins to undertake the establishment of a laboratory of psychology. At that time the only well-established psychological laboratory was at Johns Hopkins, though the year before Cattell had started his work at the University of Pennsylvania. This innovation at Wisconsin was not only the first of its kind in the Middle West, but also the first connected with a state university. Other advances soon followed: "Wisconsin was the first state in America to give a short course in Agriculture in her university. It had for its purpose the calling of young men from the farms to Madison during the winter months and training them so they could pursue a line of farming which would be more remunerative and on a much higher plane than that which then existed in the state." [16] It was largely through President Chamberlin that this course became a reality.

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[13] Pyre: op. cit. p. 283.

[14] Oral statement of C. S. Slichter to J. V. Nash, Dec. 18, 1928.

[15] Oral statement by E. A. Birge to J. V. Nash, Dec. 18, 1928.

One of Chamberlin's early students at Whitewater Normal School had been Franklin King, who would have been dropped from the school for unsatisfactory work but for the insistence of his natural science teacher, who saw promise in him. Later at Madison he appointed King to a professorship in agricultural physics—the first chair of that kind in existence. Even to this day (long after his death) the work of King is recognized the world over. "When Sir John Russell, of the Rothamstead Agricultural Station in England, visited Wisconsin he put first the work in soil physics started by King." [17]

Building up the School of Engineering was a project into which Chamberlin threw himself with much enthusiasm. For this he gathered together a very eminent staff, only to lose several of them to Leland Stanford University just before he himself went to Chicago. President Jordan was said often to have remarked that he waited to see who Chamberlin called to his faculty and then took them away with higher salaries. The disappointment over losing the pick of his engineering staff was a factor in Chamberlin's accepting the Chicago post.

In his last year at Madison, Chamberlin launched another bold project. Recognizing that no university can be great in all lines of thought but should concentrate upon certain selected lines, he decided to emphasize economics, political science, and history. Plans for a School of Economics, Political Science, and History were developed and approved by the Board of Regents, thus making it possible to give greater opportunities for graduate work and research within that unit than in the University as a whole. Because of the unusual opportunities offered for a powerful development of graduate work, he was able to secure as director of the new school, Dr. Richard T. Ely, head of the Department of Economics at Johns Hopkins University. Ely came to Wisconsin just as Chamberlin left for Chicago, but the new movement was already well under way and was destined before long to make Wisconsin great in economics, political science, and history.

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[16] Ransome A. Moore: Hoards Dairyman. October 10, 1928, p. 876.

[17] C. S. Slichter: Statement to J. V. Nash. December 18, 1928.

"It was, however, characteristic of Chamberlin that he never 'played his work up' so as to make his plans seem greater than they really were. He did not minimize their importance but he refrained even from indicating the results which the future might bring out of them. In this case he did not talk of founding a graduate school; he knew that neither the State nor the University was ready for such a movement. But just as he began his work at Wisconsin by encouraging graduate study through fellowships and by the offering of graduate courses in several departments, so the significant step which came at the close of his administration was the founding of this School which should be more specifically devoted to graduate study.

"This developmental method marked all of his administration. Chamberlin very definitely united his forward movements to the past history and the present state of the University. He did not desire revolution either in fact or in form. He advanced the University along the lines of development which, as he saw, were those that belong to a midwestern state university and were equally those along which the University of Wisconsin was ready to move." [18]

At Chamberlin's final commencement in 1892, the University for the first time granted the degree of Doctor of Philosophy for graduate work pursued at the University, although the degree had been conferred, *honoris causa,* before. It is interesting to note that the first man to receive this degree was Charles R. Van Hise, later (1903-1918) President of the University.

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[18] E. A. Birge: Statement to J. V. Nash.

In leading the institution along the path of progress from what was essentially a college into a university both in organization and in spirit, President Chamberlin had moved steadily forward in a series of successful achievements. His experience as State Geologist had given him a wide knowledge and understanding of legislatures. He had come to know that in dealing with legislatures everything is likely to go well at first, but that later the ship seems to scrape on the bottom. When that happened Chamberlin knew exactly what to do, rather by figuring it out than by instinct, for he did not have the instinct of a politician. Understanding the way in which things were likely to go, he was never surprised and did not have to improvise, which made him probably the University's most successful president in getting appropriation bills through the legislature. He knew likewise how to move in order to get measures through the faculty as well as through the Board of Regents.

For all of the larger sides of administration, according to Dr. Birge, Chamberlin was a very exceptional man. But the very qualities which insured success in these larger affairs were a hindrance to him in many small matters. He was likely to ponder over petty matters as though they were important scientific questions, whereas when a student wants to know whether he can be excused from class on Friday, so as to go home, he wants an answer, "yes" or "no," right away. Minor details piled up on Chamberlin and worried him and made the administrative work more of a burden to him than it should have been.

In 1891, when President William R. Harper was gathering together outstanding men for the faculty of the new University of Chicago, he chanced to learn that President Chamberlin might welcome a return to his scientific work, and he promptly offered Chamberlin the headship of the department of geology to be organized at Chicago. The opportunity seemed golden and Chamberlin felt that he had earned the right to accept it. In five years as president he had fulfilled his obligations and duty to the State of Wisconsin by reorganizing the University and preparing it for an even more rapid advance to follow. With a deep feeling of relief at being free from the burdens of the University presidency, he turned hopefully toward Chicago. He had been "a pioneer in the educational field, who saw the possibilities which seemed visionary at the time, but which he fortunately lived long enough to see realized and justified. The remarkable development of the University of Wisconsin which he lived to see in other hands justified his early anticipations; and it was a particular source of gratification to him that a part of this program was realized through the activities of Van Hise, whose career in geology, as well as his administrative policies, was so largely influenced by the example of his master, Chamberlin." [19] The work had been well done. "No quinquennial in the history of the University has yielded results greater, more permanent, or more beneficent," wrote President Emeritus Birge.[20]

## AT THE NEW UNIVERSITY

President Harper gathered his faculty for the new University of Chicago from the four quarters of the earth. Rarely, if ever, at the inauguration of an institution of learning, had there been brought together men of such varied academic experience and such diverse points of view. Chamberlin came because he welcomed the relief from the burdens of administrative work, but despite the fact that he had resigned the presidency of the University of Wisconsin, when it was in a flourishing state and in the face of a unanimous petition of the faculty and students that he should remain, in order to return to scientific research, he was unable to keep free from participation in the organization of the new University during its earlier years. He felt forced to accept for a time the deanship of a scientific section, the Directorship of the University Museums, and other duties in addition to the development of the Department of Geology. He became the acknowledged leader of those who urged greater freedom for the sciences and less requirements for the classics, though he favored the full development and free election of the latter.

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[19] Joseph Jastrow: Letter to J. V. Nash in 1928.

[20] Historical Sketches of Beloit College. Edward Dwight Eaton (1928), p. 253.

In those days Latin and Greek were the backbone of a general college course, and on them the student was required to focus much of his attention. President Harper's own scholarly achievements (phenomenally great for so young a man) had been in the field of the classics, and he had had little contact with the growing field of science. The University of Chicago started with what seemed to Chamberlin an overemphasis on the classics. He himself in preparatory school and college had studied Latin for eight years and Greek for five. Fully appreciating the classics, he was in no way opposed to their full development and the free election of these studies by those so inclined, but he did feel most strongly that, with the rapid extension of the domain of science, students entering the scientific fields were greatly hampered by excessive requirements of Latin and Greek. Thus started the memorable succession of debates in faculty meetings principally with Professors William Gardner Hale, of the Latin Department, and Paul Shorey, of the Greek Department, on "the Latin question." The faculty naturally was divided in sympathy, and the contest was long-continued and severe. Science gradually emerged victor in this struggle, and the vigorous efforts of Chamberlin paved the way for the great expansion of the University in scientific lines.

The University inaugurated the four-quarter system, instead of the usual two semesters, and at the close of the Winter Quarter in 1893 Chamberlin gave the University's second Convocation address. To add momentum to the movement which he was championing, he chose as his subject: "The Mission of the Scientific Spirit." Two paragraphs of this address which introduce the scientific spirit may be quoted:

"In the architecture of science, every beam is to be tested, every joint is to be put to trial. Conjectures, assertions, opinions, current impressions, preconceived notions, accepted doctrines, all alike are pushed aside to give free scope to untrammelled induction from carefully sifted evidence. The supreme endeavor is to present a disposition of fairness and openness to all evidence and all inductions. Whatever evidence demands, that it accepts. Whichever way the balance of evidence inclines, to that it leans. There is no resistance to the leadings of evidence, there is no pressing of evidence to give it greater or less than its intrinsic weight. All lines of inquiry are pursued with equal zest. All phenomena are welcomed with equal cordiality. The mind opens itself on all sides to every avenue of truth with equal impartiality.

"When demonstrative realities are brought forth they are embraced to the exclusion of all else. They displace all preconceptions, all deductions from general postulates, all favorite theories. The dearest doctrines, the most fascinating hypotheses, the most cherished creations of the imagination or of the reason are cast aside that the new light may freely enter and illuminate the mind. Previous intellectual affections are crushed without hesitation and without remorse. Demonstrative facts are placed before reasonings and before ideals, even though the reasonings and the ideals seem, from previous bias, to be more beautiful, to be more lofty, yea, even though they should seem for the time, until the clearer vision comes, to be truer. That which at the first seems absurd, that which for the time seems impossible, still ofttimes proves to be true in the light of a rectified vision of real relations. And so, the scientific spirit prompts to the acceptance of duly determined facts however they may accord with preconceived standards."

Farther on we read:

"The most significant and prophetic fact in the history of material studies is the tendency to the dematerialization of matter. Starting with the common notion of the fixity, inertness, and passivity of matter, it was discovered, step by step, that activity was a more and more pervading and potential characteristic of all forms of matter from the atom to the falsely-fixed star. It was early discovered that some of the very elements of fixity were but expressions of motion. The gyroscope was a key that unlocked a wondrous treasure-house of hidden truth. As research advanced the functions attributable to fixed solid matter diminished, until the greatest living English-speaking physicist felt warranted in advancing a kinetic theory of matter; a theory which almost completely eliminates matter as ordinarily conceived, leaving only an ulterior, fluidal, ethereal entity—for I scarcely dare say matter—which has become a basal concept in modern ultraphysics. Vortices of intense, incessant, irrotational motion are conceived to be the real units of physical phenomena. Towards this view evidence and opinion seem tending. It is not demonstrative, but it seems a prophetic vision in the line of coming truth. And so it appears but a prolongation of intellectual perspective to anticipate the entire elimination of the current view of matter as a true concept and the substitution therefor of inconceivably intense activity in a basal entity whose characters are just beginning to disclose themselves. Certain at least it seems that the future concept of matter must have as its central factor inexpressible intensity and refinement of activity. Certain it seems a picturing of the real constitution of matter must be antipodal to what we have inherited, must awaken higher sentiments and call forth the utmost resources of the true imagination."

This was in 1893: quite different was the view frequently expressed in the years immediately following, that "future advances in physics will be largely in the fifth decimal place."

In turn there were treated biologic investigations, historical inquiries, science and volition, the new humanities, philological research, literary development and religious phenomena, to bring home to the university community a realization that the scientific spirit is ideally and truly a vital factor in all advanced human thought.

"The curtains of the heavens have been folded up and laid away as the garments of our children; as things loved but outgrown. Olympus is gone. Milton's Cosmos equally with his chaos is only a picture of the past. The richest imagery of all past literature has lost its power save as a glory of the past. And this simply because it was not true. The heavens are not as they were imagined. The beauty of thought does not make it true. The loveliness of thought does not make it immortal. Only the true is enduring. We shall still love these literary myths as marvelous products of days and conditions that are gone. They rightly teach us as all past life productions teach the appreciative soul. Rightly viewed their value is even heightened by the very fact that their day is gone to return no more. The bone that lies in the gutter is a matter for the scavenger. The bone embedded in the Cambrian shales is beyond price. And so it is with the literature that marks the evolution of the thoughts and feelings of the ages. As products of the past their value is beyond estimate. As factors of present and future creations they have lost their potency."

With the beginning of 1893, three months after the University opened its doors to students, appeared the first number of the *Journal of Geology.* Its announced purpose was to serve as a medium of publication for the results of researches connected with the department, to bring to the University and its constituency some of the products of leading geologists in this and other countries, and to be a means of intercommunication between investigators throughout the world. The breadth of plan at the outset may be gathered from the imposing list of associate editors from outside the University—Archibald Geikie, Hans Reusch, Charles Barrois, Albrecht Penck, Gerard DeGeer, G. M. Dawson, O. A. Derby, Joseph LeConte, G. K. Gilbert, H. S. Williams, J. C. Branner, G. H. Williams, and I. C. Russell. The opening article of Volume I was "On the Pre-Cambrian Rocks of the British Isles," by Sir Archibald Geikie. Followed by other noteworthy contributions, reviews and editorials, the initial number of the *Journal,* in spite of the scant time available amid the chaos of the University's first quarter, compares favorably with any later issue.

To keep the *Journal* at the high level of its beginning imposed a severe task on the editor in chief, particularly in the earlier years. Contributions of desirable manuscript sometimes fell short of filling the numbers and more material was needed. A series of essays under the heading of "Studies for Students" was accordingly inaugurated to fill gaps when required. To this series both Chamberlin and Salisbury contributed from time to time descriptive and expository studies which presented in model form the latest developments of knowledge and the best thought of the times along certain lines which they selected. Though modestly addressed to students, some of these "studies" proved to be of lasting value. In this unpretentious series appeared "The Method of Multiple Working Hypotheses." So steady has been the stream of requests for copies of this little essay during the thirty-four years since it first did its duty, that it has recently (1931) been reprinted in the *Journal of Geology* in its original form.

Later, with the growth of the science, there was no shortage of manuscript and Chamberlin's own productions were oft held back to give precedence to the work of others.

# PEARY AUXILIARY EXPEDITION TO GREENLAND

Before Lieutenant Robert E. Peary left the United States in 1893 on his third trip to Greenland in quest of the North Pole, he made arrangements for an auxiliary expedition to join him the following summer and furnish his party with additional supplies should it remain for another year's work, or offer it a means of return should its work be finished. On July 7, 1894, the Peary Auxiliary Expedition, comprising Henry G. Bryant, commander; William Libbey, geographer; T. C. Chamberlin, geologist; Axel Ohlin, of Sweden, zoologist; Emil Diebitsch, civil engineer; H. L. Bridgman, historian; and H. E. Wetherill, surgeon; sailed from St. Johns, Newfoundland, in the *Falcon,* a small but staunch sealing steamer specially fitted for ice work.

Early on the morning of the 12th of July, Cape Desolation was sighted. The first glimpse of the topography of Greenland was full of suggestions. The coastal mountains were rugged in outline and rough and angular in detail. Flowing contours scarcely entered into the general view. The dominant lines of sculpture ran in vertical rather than horizontal courses, and led to the inference that they owe their fashioning to the familiar meteoric agencies that work vertically rather than to the horizontal rasping of ice flowing out from the Greenland ice cap. The bearing of this angular topography upon the problem of the former extension of the ice, and especially upon the broad question whether the ice sheet of Greenland once crossed the Baffin basin and became the source of the North American glaciation, as held by some geologists, at once presented itself and stimulated a careful scrutiny of the topography throughout the whole length of coast northward to Peary's headquarters on Inglefield Gulf.

As the *Falcon* steamed slowly northward it was found, however, that angularity was not a universal feature, but that it alternated with very considerable tracts of flowing outlines of glaciated aspect. In fact, about one-half of the western coast of Greenland between Cape Desolation and Inglefield Gulf, a stretch of some seventeen degrees of latitude, presented angular and apparently unglaciated contours, whereas the other half presented subdued outlines indicating former glaciation. North of Cape York, Chamberlin found two islands of such significantly different configuration, though composed of almost identical gneissic rock, that they have since become the familiar textbook illustrations of a rugged conical island before and after an ice sheet has passed over it. Dalrymple Rock, near the Greenland coast about 77° north, is exceptionally jagged and rugose, with no signs of glacial abrasion either in its general configuration or in its surface details. Quite in contrast are the Carey Islands out in the middle of North Baffin Bay, thirty miles to the west northwest, which have been worn smooth in outline. Striae on their scoured surfaces show glacier movement from the north coming from Smith Sound rather than from the Greenland coast. On Southeastern Carey Island were also found erratics of limestone, sandstone, shale, and quartzite wholly unlike anything seen in the islands themselves or known to occur on the mainland of Greenland to the eastward, but such as might apparently have come from the sedimentary series of Grinnell Land and the extreme northwestern coast of Greenland. The natural pathway of the ice bearing these boulders would be through Kennedy Channel, Kane Basin, and Smith Sound. But that ice did not extend as far as Dalrymple Island near the Greenland shore.

Later a small driftless area was found near Peary's camp on Bowdoin Bay, indicating that the former glaciation in this region did not extend greatly beyond the limits of the present glaciers. From these and other lines of evidence Chamberlin came to the conclusion that, although the ice of Greenland formerly extended somewhat beyond its present limits, it did not have any great amplification during the glacial epoch, at least in a westerly direction. Greenland was not the source of the vast ice sheets which spread over much of northern North America during Pleistocene times, as many had previously thought.

After many struggles with the Baffin Bay ice pack, at times following narrow lanes of open water amid the floe ice, at other times crashing full speed into the ice to split it asunder, the *Falcon,* on July 25, reached Murchison Sound, the northern entrance to Inglefield Gulf. Peary's headquarters were at the head of Bowdoin Bay some thirty-five miles up the Gulf, but the ice pack was late in breaking up that summer and a week elapsed before the camp was finally reached.

In their attempt to cross the great ice cap to the northern end of Greenland, Lieutenant Peary's party had encountered a succession of terrific storms, which, together with the death of many of the dogs drawing the sleds, had forced a return to the base camp and the abandonment of the project for the year. Although most of his party were greatly discouraged, Peary himself was undaunted and decided to pass another winter on Bowdoin Bay with a few of his stouter-hearted companions and to try again to cross the ice in the following spring. After unloading its supplies the *Falcon* left for three weeks of exploration along the coast of Ellesmere Land, before starting back south. Chamberlin thus had three weeks for a study of the glaciers of the neighborhood under a never-setting sun.

The results of this strenuous work have been presented as "Glacial Studies in Greenland," in the *Journal of Geology;* in his presidential address before the Geological Society of America in 1895, and later in more scattered form in textbooks. Glaciers in temperate latitudes, as is well known, end in slopes of moderate declivity, thinning and disappearing at their margins as a consequence chiefly of progressive surface melting. Chamberlin found that this habit prevails with the Greenland glaciers as far north as Disco Island and even somewhat beyond. But in Inglefield Gulf, between the latitudes of 77 and 78 degrees, the glaciers end in abrupt terminal walls rising to heights of 50 to 150 feet. This peculiarity he interpreted as being due to the fact that in this high latitude the sun's rays are at a low angle and are directed against the ice from all points of the compass during the continuous daylight of the summer.

Chamberlin described the pronounced stratification of the ice as the most impressive feature displayed in the vertical sides of these high-latitude glaciers. As contrasted with the glaciers of the Alps, the remarkable extent, the definiteness, and the peculiar characteristics of the stratification displayed in the vertical walls of these northern glaciers were a veritable revelation to him. On the vertical ice faces there were characteristically two notable zones, an upper inconspicuously laminated one of nearly pure white ice, and a lower one whose laminated structure was made very conspicuous by the presence, along very numerous parting surfaces, of rocky débris ranging from fine silt to boulders. This débris was in very definite and limited horizons, leaving the ice clean and pure above and below. In general, the abundant débris was confined to the lower fifty or seventy-five feet of the glacier.

The question of foremost importance was the origin of the stratification, or foliation, and the method of introduction of the débris. "The original stratification could not have been very pronounced. Perhaps it was intensified somewhat during subsequent consolidation, but some new agency was necessary to produce the more definite partings and to introduce the layers of débris. This agency appears to have been a shearing movement between the layers."[21]

On almost every one of the vertical faces certain layers were found to jut out sharply over those beneath. The phenomenon suggested differential movement between layers, but the possibility that it had resulted instead from differences in melting raised doubts as to the truth of the explanation. More direct proof was sought in grooves or flutings which cobblestones might be expected to make if movement occurred between the layers. Such were found. But the best evidence of the verity of shearing between layers was the intrusion of the earthy material itself along planes of slippage. This process Chamberlin was fortunate enough to observe in actual operation in places where a glacier was overriding embossments of rock. That internal shearing plays an important part in the movement of glaciers seemed thus to be demonstrated.

The many other features of the well-rounded glacial studies consummated in these three weeks must be passed over, but when, on August 26, the *Falcon* turned her prow southward and Lieutenant Peary left the ship to spend another dreary winter in the Arctic, it seems to have been generally remarked that the only member of the party who had accomplished what he set out to do was Professor Chamberlin.

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[21] Recent Glacial Studies in Greenland. Bull. Geol. Soc. Amer., Vol. 6 (1895), pp. 206-208.

## MULTIPLE GLACIATION IN NORTH AMERICA

The first formal attempt to define and name the multiple glaciations of North America was that of Chamberlin which appeared in 1894 in the third edition of "The Great Ice Age" by James Geikie. His classification was as follows:

*Glacial Period*

1. Concealed under series (theoretical)—Unknown.
2. Kansan stage of glaciation—First (represented) glacial epoch.
3. First interval of deglaciation—First interglacial epoch.
4. East Iowan stage of glaciation—Second glacial epoch.
5. Second interval of deglaciation—Second interglacial epoch.
6. East Wisconsin stage of glaciation—Third glacial epoch.
7. Later oscillations of undetermined importance—Final glacial epoch embracing possibly a fourth glacial epoch.

W J McGee had distinguished two glacial drift sheets in Iowa, an "upper till" and a "lower till," separated by a bed of interglacial accumulations not everywhere a "forest bed" but conveniently so styled. McGee had worked chiefly in northeastern Iowa, but had reconnoitered the area south and west of the Des Moines lobe of Wisconsin age and had there identified the same group of sheets which he had long studied in northeastern Iowa. Chamberlin, however, in a reconnaissance along the route of the Burlington railway in southern Iowa, had seen the extensive excavations recently made to get ballast for the road, and particularly the deep cuts made between Afton and Thayer in improving the grade across the Grand River Valley. McGee had not visited this most promising locality. Since they could not understand one another's descriptions, they held a field conference in 1893, divided between the areas of their more special studies. McGee's interpretation thus centered on northeastern Iowa, while Chamberlin's centered on the Grand River localities *in the south central summit region of Iowa.* These seemed to be in general harmony, though today we know that a portion of northeastern Iowa is surfaced by a younger drift not occurring in central and southern Iowa.

Shortly after this field conference, Chamberlin was asked by Geikie to prepare the chapters on the glaciation in North America for his well-known work, "The Great Ice Age." This invitation was the immediate occasion for framing and publishing the mode of interpretation, correlation, and nomenclature given above.

"At the outset this scheme recognized only three ice invasions of the major type. The bed of till lying on Paleozoic rock at the bend of the Grand River, about a mile southeast of Afton Junction, was taken as the type locality of the glacial sheet left by the first ice invasion. It was named Kansan from the belief that it belonged to the same horizon as the old patchy drift on the rise toward the Ozarks south of the Kansas River, and that it represented the farthest extension to windward of the North American ice invasions. The Kansan formation at this typical locality was also made to include the kame-like deposits shown in the four trenches nearest Afton Junction. The original description in *The Great Ice Age* (page 757) was placed under the sidehead, 'Kansan formulation.' It includes this statement, 'there occur buried lenticular masses of gravel that appear to be kames formed on the surface of this deposit (the original Kansan) and subsequently buried by till belonging to the next higher formation' (the original Iowan).

"In the original text the Aftonian (interglacial deposit between first and second drifts) was not characterized by gravels but by the direct evidence of an interglacial interval, such as soils, muck, peat, twigs, limbs, trunks, fossils, etc. (*The Great Ice Age,*" pp. 757-759). No stress has ever been laid on gravels by the proponent of the scheme of 1894. In so far as gravels were associated with these direct evidences, they were usually gravels of the horizontal stream type as already stated.

"The very exceptional exposures of the upper till in the Thayer-Afton Junction region were regarded as the product of the second ice invasion. They embrace the greatest summit formations in Iowa and constitute the most representative glacial formation of that state. Even in 1894, it was practically known to occupy a wide belt at the surface embracing and running under the Des Moines lobe of the third (Wisconsin) ice invasion."[22]

"In the two years following the publication of the correlation of 1894, it was shown by reconnaissances that the upper till sheet, the original Iowan, extended farther south than it was represented on the map in *The Great Ice Age*. Bain held, on the basis of a reconnaissance, that it extended to the state of Kansas. This indicated that the second ice invasion was more nearly coextensive with the first than had been assumed with unnecessary conservatism. This increased the importance of the Iowan and added weight to the priority that had been given it. It was preeminently worthy to bear the state name as it was the most outstanding glacial formation in Iowa.

"Up to this time, it had been natural, as well as conservative, to assume, in the absence of evidence to the contrary, that the old glacial sheets in Illinois were contemporaneous with the old sheets in the trans-Mississippian region. But almost simultaneously with the issue of a three-fold division of the system of 1894, Leverett found that one of the older ice sheets of Illinois had crossed the Mississippi and overlapped the upper sheet of the west side. He also found evidence of a notable interval between the overlapping sheet and the formation of the preceding surface. This was fully confirmed later, and in 1896 the Illinoian invasion was added to those previously named, making four in all.

"As these four glacial invasions are all that now (1928) seem worthy of recognition, it will help to give definiteness to our sketch of the history of the shifting of names that followed, to give the four here in tabular form.

4. The fourth glacial invasion, Wisconsin.
3. The third glacial invasion, Illinoian.
2. The second glacial invasion, Iowan.
1. The first glacial invasion, Kansan."[23]

Most unfortunately the two years following the publication of the system of 1894 in "The Great Ice Age" were marked by so many shifts of terms and correlations that it is difficult for the ordinary reader or the busy geologist to follow the history with accuracy. The shifts followed one another in almost kaleidoscopic frequency and complication.

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[22] T. C. Chamberlin: The Development of the Theory of Multiple Glaciation in North America. (Unpublished manuscript, March, 1928, pp. 16-18.)

[23] Ibid., pp. 19-20.

The attempted emendations began in 1895 with the recognition by Calvin that the surface drift in the northern portion of Johnson County, in east central Iowa, was much younger in age than the drift surfacing the southern portion of the county, and that there were thus three instead of two pre-Wisconsin tills in McGee's area. In the northern part was a thin, patchy drift of young aspect, covering the much thicker drift (the middle sheet of the three-fold division) which was the surface formation to the south.

McGee had used the terms "lower till," "forest bed," "upper till." Chamberlin's scheme used Kansan, Aftonian, Iowan, terms not used previously. Chamberlin always believed firmly that McGee's "upper till" was, in the main, the great surface sheet of southern Iowa (the second drift or upper till in Chamberlin's type section near Afton), but included also in northeastern Iowa the thin local cover sheet which Calvin, in 1895, differentiated as the third drift. His own system of 1894 took no cognizance of this cover sheet, which came to be appreciated later and which is confined to northeastern Iowa, but only recognized the main mass of McGee's upper till, keeping to the fore the splendid exposures in the Afton region, far beyond the southern limits of the cover sheet. He had temporarily attached the prefix *East* to the state names, Wisconsin and Iowan, as a prudential measure to guard against a possible misuse of the unqualified state names, for he felt that only the best exhibit of a given state should, as a rule, bear the unqualified state name, and that too little was then known of the glacial formations of northwest Wisconsin and western Iowa to warrant the unqualified use of the names Wisconsin and Iowan for formations which had only been intensively studied in the eastern halves of these states. Later he regretted this excessive scrupulousness, as the prefixes were only so much lumber and even led frequently to misinterpretation. They were soon discarded when no longer needed.

The Iowa Geological Survey began in 1895 to give particular attention to the local cover sheet and adopted the view that McGee's upper till was merely this cover sheet of northeastern Iowa rather than the great sheet on which it rests and which is the surface drift over a large part of the state beyond the confines of the cover. The Survey then went further and proceeded to use Chamberlin's term Iowan for the cover sheet and his term Kansan for the greater sheet below and beyond, which Chamberlin had called Iowan. This use of Chamberlin's names was then given much currency in the Iowa county reports which were coming out in rapid succession. Bain later went to the Afton region and found that these names, as the Iowa geologists were then using them in northeastern Iowa, did not fit Chamberlin's type sections. He might now have recognized the Afton sections as the basis of Chamberlin's published nomenclature, and in accordance with the claims of priority have brought the newer developments in northeastern Iowa into harmony with it. Instead he shifted Chamberlin's names to fit his own ideas of northeastern Iowa, transferring the name Kansan, which Chamberlin had used for the first drift, to the second drift which Chamberlin had named Iowan, thus leaving the first drift without a name and divorcing the term Iowan from its type sections near Afton and Thayer. The Iowa county reports then came to use the succession, sub-Aftonian or pre-Kansan, Kansan, Illinoian, Iowan, and Wisconsin.

Perhaps nothing showed more plainly the restraint, patience, and generously friendly character of Chamberlin than his reception of these developments. He revisited Thayer and Afton with Bain, who later was to take graduate work and the doctor's degree under him at Chicago, and also went over other parts of Iowa as guest of the State Survey. The problems were complicated and confusing, and he was able to appreciate alternative points of view. In a very generous spirit he acquiesced, though inwardly with considerable misgiving. In later years, when he saw the fuller relationships of the glacial succession and was convinced that a very unfortunate mistake had been made, he deeply regretted having allowed his kindly impulses to overcome his judgment.

The difficulty had arisen from a difference of opinion as to the proper interpretation of McGee's lower and upper till with separating forest bed, which even today is a debatable question. More particularly it arose from making an interpretation so open to doubt the basis of a correlation and nomenclature to which the whole American glacial succession was to be adjusted. The uncertainty of the premises may be illustrated by quoting from a paper by Calvin in 1898:

> "McGee looked upon the forest bed as the plane of division between his lower and upper till, but later investigators following the lines which he pointed out have reached the conclusion that his lower till embraces two distinct drift sheets, and that it is between these two that the forest bed invariably lies. Thus there are three drift sheets in northeastern Iowa, and in the recent literature referring to Pleistocene geology they are known respectively as sub-Aftonian or Albertan, Kansan and Iowan. No forest material has been observed between the Kansan and the Iowan, but in this situation there occur extensive beds of stratified sands and gravels."[24]
>
> "Calvin believed that in northeastern Iowa the forest bed was 'invariably' between the sub-Aftonian and Kansan tills."[25]

Though the names have been shifted, this recognition that the forest bed, as then known, was between the first and second drifts and not between the second drift and the cover sheet is in perfect accord with Chamberlin's classification. The cover sheet, not recognized by Chamberlin but subsequently differentiated, accordingly becomes a separate unit to be named and fitted into its proper place in the sequence. More recently patches of forest bed have also been found between the second drift and the cover sheet.

In the cut of the Chicago Great Western Railroad near Oelwein, in northeastern Iowa, were found three drifts with a distinct forest bed between the lowest drift and the intermediate drift. Bain wrote: "A review of sections published by McGee makes it more than doubtful whether the forest bed which he has so clearly shown to be present does not mark the Aftonian rather than the Buchanan horizon between the two upper tills."[26]

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[24] Samuel Calvin: The Interglacial Deposits of Northeastern Iowa. Iowa Acad. Sci., Vol. V (1898) pp. 64-70.

[25] George F. Kay: History of the Investigation and Classification of the Pleistocene Deposits of Iowa. Iowa Geol. Surv., 1928, p. 20.

Kay, however, thinks that there is good argument in defense of the policy followed by the Iowa Geological Survey, if proper emphasis is given to McGee's description of his two tills, their mapping, and his forest bed or gumbo, rather than too great stress given to his forest bed alone. He continues: "At the time the Oelwein cut was described gravels and sand only had been found by Calvin and his assistants in sections separating the Iowan from the Kansan, whereas McGee emphasized the number of well records in which a forest bed separated his Lower Till from his Upper Till. Since, as stated above, it is now known that in McGee's area there is in places a forest bed at the same stratigraphic horizon as the Buchanan sands and gravels and a forest bed at the stratigraphic horizon of the Aftonian, quite naturally McGee's forest bed in some of his sections is the forest bed between the Kansan and the Iowan, as these names are now applied, and in others the forest bed lies between the Kansan and the pre-Kansan."[27]

Here would seem to be the probable truth of the matter. In some places McGee's upper till was the second drift; in other places it was the second drift plus the cover sheet where that was also present; in still other places it was probably merely the cover sheet. Stratigraphically, McGee was lumping together in many places two distinct drifts, a thick and a thin one; topographically, he noted more particularly the characteristics of the thin local cover in northeastern Iowa. In this pioneer grouping together of different glacial units lay the germ of the unfortunate proceedings which followed. Nothing composite, however, characterized Chamberlin's Grand River section near

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[26] H. F. Bain: Relations of the Wisconsin and Kansan Drift Sheets in Central Iowa, and Related Phenomena. Iowa Geol. Surv., Vol. VI, 1896, pp. 466-467.

[27] George F. Kay: Op. cit. p. 21.

Afton Junction in south central Iowa, which showed the first drift, which he called Kansan, and the second drift, which he called Iowan and without a later drift to cause confusion. But still the Iowa Survey shifted the very appropriate nomenclature of the splendid Grand River type section to fit the debatable interpretations farther north.

In the years which have followed, the comparatively insignificant cover sheet, carrying the name Iowan, has been an embarrassing member of the North American glacial succession and has occupied an uncertain position. The U. S. Geological Survey party engaged in correlating the older drifts around the driftless area in 1906-07 even tested out carefully the hypothesis that there was ***no such distinct drift sheet,*** but in the end became convinced of its existence. Later it was regarded by some as possibly the Keewatin equivalent of the Illinoian. But the very recent studies of Kay and Leighton seem now to demonstrate that it represents an early advance of the last great ice invasion, which we call the Wisconsin.

Thus, by a poetic irony of fate, the second drift which is ***the*** great drift sheet of the state of Iowa is now known as the Kansan, and the so-called Iowan glaciation of the Iowa geologists is apparently now to be taken out of the category of major ice invasions and reduced to a sub-stage of the Wisconsin. With four instead of the anomalous five major ice invasions, the American glacial succession comes into harmony with that of Europe.

Chamberlin did not live to see this last development, but in his later years he cherished the hope that respect for the claims of priority, coupled with the greater appropriateness of his terms, would lead to an ultimate return to the sequence, 1. Kansan, 2. Iowan, 3. Illinoian, and 4. Wisconsin, leaving the status of the cover sheet to be adjusted later. Iowa would then be restored to the prominence and prestige in Pleistocene nomenclature to which the state is so justly entitled. In his last year he started steps to bring this about, and had he lived longer his leadership might, perhaps, have accomplished it.

## GEOLOGIC CLIMATES

Glacial geology had been Chamberlin's chosen field up to the middle nineties of the last century. By this time field studies had given a fair understanding of the main features of the Pleistocene glaciation of the country, and competent observers were actively engaged in advancing this knowledge through systematic areal investigations. Chamberlin's interest now spread to the larger scientific implications of glaciation. He turned in particular toward the causes of glacial climates which naturally led to a broader consideration of the changing climates of the geologic past. These, in their turn, were to prove but the first steps of that long flight of stairs which he was to mount steadily for thirty years till he reached the heights in cosmogony and fundamental geologic philosophy. The ascent throughout was laborious and difficult, but each step led directly to the next. The whole was a sustained effort remarkable alike for steady systematic progress into the unknown and for the far-reaching results finally achieved.

He began by considering the earth's atmosphere. "All our attempts at the solution of climatic problems proceed on some conscious or *unconscious* assumption concerning the extent and nature of the atmosphere at the stage involved."[28] Accumulating geologic evidence seemed to him to indicate no radical differences between the atmosphere in Paleozoic time and that of the more recent ages. Very opportunely signs of glaciation far back in the Paleozoic were then beginning to be found, and Chamberlin was quick to grasp their great significance. Belief was then nearly universal in an earth gradually cooling off from an original fiery state. The Laplacian nebular hypothesis had led directly to the view that the earth's early atmosphere was an enormous mass of hot vapors and gases surrounding a molten globe. Fifty times our total present atmosphere was the estimated amount of atmospheric carbon dioxide later to become locked up in our extensive carbonate rocks and coal deposits. The great hot primordial atmosphere was thought to have diminished to its present volume with the passage of time and earth climates to have become progressively cooler. But glaciation early in the earth's history and the vast original atmosphere, rich in carbon dioxide, postulated in accordance with the Laplacian hypothesis, were apparently incompatible. Chamberlin then examined the postulate of a once-molten globe with heavy uncondensed atmosphere and then, in turn, the basis for it in the nebular hypothesis at that time practically universally accepted. But the careful scrutiny which he gave the nebular hypothesis developed unsuspected weaknesses of a serious nature. As the foundations of the hypothetical structure began to crumble before his analysis, Chamberlin boldly ventured to question not only the verity of the supposed original molten state of the earth but the correctness of the time-honored Laplacian hypothesis itself.

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[28] "A Group of Hypotheses Bearing on Climatic Changes." Jour. of Geol., Vol. V (1897), p. 653.

But he was not one to tear down without trying to build something better in its place. Even in his 1897 contribution on climatic changes there was already entertained the alternative hypothesis that the earth may have grown as a solid body by slow accretion of meteoroidal material. A source of the earth's heat was found in self-compression through rearrangement of this heterogeneous material under the force of gravity. From within such an earth the atmosphere could be resupplied by volcanic and other exhalations in proportion as its gases were lost. Through losses and resupply, an atmosphere fluctuating only moderately about an equilibrium value seemed to be possible, and a vast, hot atmospheric envelope, with all its attendant geologic consequences, was therefore no longer a necessary deduction.

Current conceptions, both of the early atmosphere of the globe and of the origin of the earth itself, were plainly subject to the gravest doubt; alternative hypotheses to replace them were already in view. The way was thus opened for a study of geologic climates on a new basis, and a better theory for the origin of the solar system became one of the greatest needs of geology. To both of these great problems Chamberlin now directed his attention. The climatic studies matured first.

Some fifty years earlier Tyndall had suggested that glaciation might be dependent upon depletion of the atmospheric carbon dioxide whose peculiar competence to retain solar heat he had demonstrated. This suggestion, however, had failed to find much acceptance, partly from doubt as to its adequacy and partly from lack of any definitely assignable cause for the requisite intermittent depletion. Arrhenius, in 1896, endeavored to ascertain what degree of depletion of the carbon dioxide of the present atmosphere would bring on the conditions of Pleistocene glaciation and what degree of enrichment would produce the warm climate of the Tertiary. He reached the conclusion that the removal of 38 to 45 per cent of the present carbon dioxide would bring on glaciation, whereas an increase of 2.5 or 3 times its value would produce the mild temperatures of Tertiary times.

Chamberlin investigated the geologic setting and supplied the possible mechanism. Following the greater diastrophic revolutions the lands are relatively high and the land surfaces of the globe reach their greatest areal extent. At such times of unusually extensive exposure of the rocks, carbon dioxide from the atmosphere enters into chemical combination with the rocks, in the process of carbonation of the silicates, to an exceptional degree. This reduction in the amount of carbon dioxide in the atmosphere lowers its temperature by permitting more rapid radiation of the sun's heat from the earth. The oceans in turn become cooler and consequently absorb more carbon dioxide from the atmosphere. This further removal of carbon dioxide from the atmosphere results in a still further lowering of its temperature. Water vapor in the atmosphere also plays its appropriate part, and other processes are involved. Cold climates result.

On the other hand, during times of baseleveling, when shallow seas have spread widely upon the continents protecting great areas of rock from carbonation, carbon dioxide is freed in large quantities as the calcium bicarbonate in the sea water becomes changed to the monocarbonate in the development of the extensive limestone deposits so characteristic of such times.[29] With enrichment of the atmospheric carbon dioxide the earth is favored with warm, equable climates, such as have prevailed during much of geologic time. During such epochs the geologic record shows that temperate and tropical faunas and floras have spread strongly poleward.

The fluctuating climates of the earth manifestly have resulted from the interplay of a large number of variable factors. The extreme complexity of the processes in operation and the delicate adjustments that maintain a general equilibrium and have permitted fluctuation only between comparatively narrow limits of temperature made this a problem requiring for its solution the fullest understanding of what was involved and the keenest analysis. In 1900, Chamberlin presented his study of the intricacies of this problem and his working hypothesis of the important part played by fluctuating atmospheric carbon dioxide.[30]

An auxiliary agency in the control of secular climates appeared in possible reversals of the direction of water movement in the deeper portion of the oceans.

"In an endeavor to find some measure of the rate of the abysmal circulation, it became clear that the agencies which influenced the deep-sea movements in opposite phases [poleward or equatorward] were very nearly balanced. From this sprang the suggestion that if the relative values were changed to the extent implied by geological evidence there might be a reversal in the direction of the deep-sea circulation and that this might throw light on some of the strange climatic phenomena of the past and give us a new means of forecast of climatic states in the future."[31]

The most important opposing agencies are differences in temperature, including freezing and thawing, and differences in salinity of the ocean waters. In so far as evaporation exceeds precipitation in the low latitudes, it results in an increased salinity of the superficial waters and a tendency of these to sink and flow poleward. On the other hand, the lower temperatures of the high latitudes, and the exclusion of salts from freezing sea-water, increase the density of the water and tend to cause it to sink and flow equatorward. At the present time the polar agencies control the deep-sea circulation; the deep waters, even beneath the tropics, are cold, and the climate is rigorous and diversified. Although today we enjoy considerable amelioration of the more severe glacial climates of not long ago, the deep-sea circulation still remains equatorward as presumably it was also throughout the Pleistocene glacial epoch.

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[29] "The Influence of Great Epochs of Limestone Formation upon the Constitution of the Atmosphere." Jour. of Geol., Vol. VI (1898), pp. 609-21.

[30] "An Attempt to Frame a Working Hypothesis of the Cause of Glacial Periods on an Atmospheric Basis." Jour. of Geol., Vol. VII (1899), pp. 545-85.

[31] "On a Possible Reversal of Deep-Sea Circulation and Its Influence on Geologic Climates." Proc. Amer. Phil. Soc., Vol. XLV (1906), pp. 33-43.

Chamberlin's survey of the existing temperatures and salinities of the ocean made it clear that the battle between temperature and salinity is a close one and that no profound change is necessary to turn the balance. To him it seemed that the lowering of lands by the baseleveling processes with resulting spread of the seas on the continents and accompanying warming of the atmosphere, partly through increased carbon dioxide and partly due to other causes, would be likely to render evaporation and salinity dominant and reverse the deep-sea circulation. Warm waters descending in the equatorial regions, moving poleward and rising to the surface in the high latitudes would constitute a veritable hot-water heating system delivering heat in the polar regions and giving the whole globe the mild, equable climates which the geologic evidence indicates have prevailed, interspersed with occasional epochs of glaciation, through most of the geologic past.

The correlation of climates with the pulsations of geologic history, specifically the relatively short diastrophic upheavals and the longer intervals of baseleveling and sea-transgression is beautifully shown by the geologic record. The transcendent importance of these relations in any adequate concept of the typical geologic period, either from the point of view of the physical history or that of the biologic response to the physical conditions, should have been apparent long ago. Yet very few geologists seem to have realized this. Few, indeed, have any convictions, pro or con, on the solidarity of the hypothesis of the reversal of the deep-sea circulation, presented a quarter of a century ago. If true, it was a contribution of far-reaching significance and should play a vital part in fundamental geologic philosophy; if faulty, there is still a great gap entirely unfilled.

## THE REPLY TO LORD KELVIN

In 1897 Lord Kelvin delivered his famous address before the Victoria Institute on "The Age of the Earth as an Abode Fitted for Life." In that address he took up the question of loss of heat from a cooling molten earth and the longevity of the sun as a highly heated body, and from his analytical studies asserted with a finality unusual in scientific discussions that the age of the earth was more than twenty and less than forty million years, and probably much nearer twenty than forty million years. Geologists and biologists had been requiring much greater lengths of time for the recorded history of the earth and the evolution of its inhabitants. To be denied this seemingly necessary span of time was disconcerting, and yet so great was the prestige of Lord Kelvin in the field of mathematical physics that the age limits which he placed on the earth and its evolution had scarcely less force than a supreme court decision.

Geologists, according to Kelvin's conclusions, had been very extravagant in their time postulates. Possibly the scientific public carried the implications even further, for the address had been "permeated with an air of retrospective triumph and a tone of prophetic assurance." At best the geologists were in a position of uncertainty between the dictum of exact science on one hand and faith in their own methods and criteria on the other.

For some reason Kelvin's address was reprinted in *Science* in May of 1899. Chamberlin now promptly and boldly challenged Lord Kelvin along the whole front of his argumentative position.[32] Not only did he show the weaknesses of his geologic assumptions, but he took him to task more particularly on the basis of physical laws and physical antecedents. The stroke was as unexpected at that time as today it seems remarkable in the light of subsequent advances in physics. Not a few British scientists expressed surprise that anybody should have the temerity even to reply to Lord Kelvin, let alone to attempt to unhorse him in his own field. Yet the latter is precisely what was done, in ways that can be appreciated much better now than at that time.

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[32] Science. Vol. IX (1899), pp. 889-901 and Vol. X (1899), pp. 11-18.

Let us follow merely Kelvin's third line of argument which was drawn from the theoretical age of the sun. Accepting the Helmholtzian theory that the sun's heat is solely the result of its contraction, Kelvin calculated that the sun could not have supplied sufficient heat for life on the earth for more than twenty to thirty million years. Let us now read Chamberlin's reply, keeping in mind as we do so that it was given before any of the remarkable developments in physics during the last few years, particularly the discovery of electrons, the complex structure of atoms, and the prodigious amounts of energy now known to be locked up in atomic structure. With our present concepts of atomic physics in mind, we may appreciate the extraordinarily prophetic vision developed in the following paragraph which Chamberlin wrote in 1899.[33]

"Here is an unqualified assumption of the completeness of the Helmholtzian theory of the sun's heat and of the correctness of deductions drawn from it in relation to the past life of the sun. There is the further assumption, by implication, that no other essential factors entered into the problem. Are these assumptions beyond legitimate question? In the first place, without questioning its correctness, is it safe to assume that the Helmholtzian hypothesis of the heat of the sun is a complete theory? Is present knowledge relative to the behavior of matter under such extraordinary conditions as obtain in the interior of the sun sufficiently exhaustive to warrant the assertion that no unrecognized sources of heat reside there? What the internal constitution of the atoms may be is yet an open question. It is not improbable that they are complex organizations and the seats of enormous energies. Certainly, no careful chemist would affirm either that the atoms are really elementary or that there may not be locked up in them energies of the first order of magnitude. No cautious chemist would probably venture to assert that the component atomecules, to use a convenient phrase, may not have energies of rotation, revolution, position and be otherwise comparable in kind and proportion to those of a planetary system. Nor would he probably feel prepared to affirm or deny that the extraordinary conditions which reside in the center of the sun may not set free a portion of this energy. The Helmholtzian theory takes no cognizance of latent and occluded energies of an atomic or ultra-atomic nature. A ton of ice and a ton of water at a like distance from the center of the system are accounted equivalents, though they differ notably in the total sum of their energies. The familiar latent and chemical energies are, to be sure, negligible quantities compared with the enormous resources that reside in gravitation. But is it quite safe to assume that this is true of the unknown energies wrapped up in the internal constitution of the atoms? Are we quite sure we have yet probed the bottom of the sources of energy and are able to measure even roughly its sum-total?"

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[33] Science. Vol. X (1899), p. 12.

This sounds like inspired prophecy! Substitute our present word "electrons" for Chamberlin's "atomecules" and the vision of 1899 is almost uncanny in its prophetic correctness. That Chamberlin should thus have anticipated, by almost a quarter of a century, in form as well as in substance, some of the most basal concepts of modern physics was, as Professor Moulton has recently said,[34] in some sense accidental, but that he saw that there were these energies, that there *must be* some such energies, instead of being accidental, was the result of mature reflection upon a whole range of phenomena whose import he saw with remarkable clearness.

Even in 1899, when the full significance of this reply could not be appreciated, its effect on geologic thought was prompt and decisive; Lord Kelvin's time restrictions never bothered geologists thereafter. Significant also was the reply in showing how far its author had already advanced in those fundamental researches which later grew into an almost complete geologic philosophy.

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[34] F. R. Moulton: The Planetesimal Hypothesis. Science, Vol. LXVIII (1928), pp. 10-12.

## THE PLANETESIMAL HYPOTHESIS

The study of ancient geologic climates disclosed facts which seemed to Chamberlin inconsistent with the common belief growing out of the Laplacian hypothesis that a hot, vaporous atmosphere of enormous extent surrounded the earth during its early stages. Tested by means of the molecular velocities, after the method of Johnstone Stoney, the supposed vast atmosphere was found to be an impossibility. This conclusion naturally led back one step further to the question of whether there was a basis for the view in the Laplacian nebular hypothesis, and eventually raised question as to the correctness of that time-honored theory of the beginning of the earth.

The earth-moon ring postulated by Laplace was put to the test and it was found that this supposed ring could not remain in a true gaseous state under the conditions required by the hypothesis. Chamberlin, therefore, began to consider the alternative possibility of molecules or particles revolving in independent orbits in planetoidal fashion. Condensation from such a state had been generally held, though without sufficient reason, to give rise to retrograde rotations, whereas most of the rotations of the solar system are forward. But Chamberlin, by a further analysis of the problem found grounds for concluding that, on account of the ellipticity of the orbits, forward rotations will in general result from the gathering together of individual particles. The importance of this conclusion was very great for it indicated the tenability of an alternative method of earth genesis. Instead of a single mode of genesis, it now became a question of which of two alternatives was better in accord with molecular behavior and recognized mechanical principles.

The next step was to apply critical tests to the Laplacian hypothesis along as many different lines as possible. Professor F. R. Moulton, who had been collaborating with Chamberlin from an early stage in these cosmogonic studies, brought to bear his mastery of celestial mechanics and his mathematical insight and contributed brilliantly to the success of their joint investigations. The two men were very different in their training, points of view, and methods of analysis. One was naturalistic, the other mathematical; together they made an ideal team, each supplementing the other. They worked so closely and informally together that the precise parts which each played in disproving the Laplacian hypothesis and in developing the planetesimal hypothesis to replace it are not readily separated and will not be differentiated here. They have been unscrambled to some extent by the authors themselves in a joint statement called forth by certain not over-careful criticisms and captures by other workers in related fields.[35] The credit belongs to both.

The searching tests by Chamberlin and Moulton proved conclusively the untenability of the Laplacian hypothesis. This famous theory failed to meet the requirements along a dozen different lines, and they formally and finally abandoned it in 1900. But so firmly entrenched in the scientific thought of the time was this beautifully harmonious hypothesis, and so great is the inertia of inherited ideas, that Chamberlin frequently remarked that he expected a quarter of a century would elapse before the geological and astronomical professions as a whole would finally give it up for something better. It is interesting to note that the date given in Moulton's new Astronomy (1931) for the general abandonment of the Laplacian hypothesis is 1925.

On the constructive side considerable futile work was done, largely by Chamberlin, in trying out the possibilities of collision between nebulous bodies, "but no escape was found from the high probability, amounting almost to certainty, that the resulting orbits would be too eccentric to fit the case of the solar system in any instance that was likely to occur."[36] He proceeded to a study of the effects of the differential attractions exerted by bodies on one another when they make close approaches, as developed by the researches of Roche, Maxwell, and others, and found this a promising field. Not only was the chance of close approach vastly greater than that of actual collision, but in addition to the direct tidal effect he recognized also "the projective effect developed in a body of enormous elasticity already under high pressure and affected by violent local explosions which were subject to intensification by the changes of gravity brought to bear on them by a passing body.[37] The disruption of solid bodies was seen to afford a basis for explaining the clustered fragments of comets and the angularity of the meteorites into which they are supposed to be finally dispersed. The explosive projections from suns under the influence of a passing body were thought to explain the two-armed spiral nebulæ which were then coming into prominence as the dominant type of nebula in the heavens.[38]

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[35] "The Development of the Planetesimal Hypothesis." Science, Vol. XXX (1909), pp. 642-45. This statement has been reprinted together with the seven attacks and counter attacks which preceded it (Science, April 23, 1909, to November 5, 1909) under the title: "Our Friends, the Enemy, a Discussion bearing on Scientific Ethics, with Concrete Illustrations." Idem. (1909), pp. 21.

[36] Science, Vol. XXX (1909), p. 644.

Following these preliminary steps, which cleared the way by narrowing the limitations of tenable hypotheses and which defined and developed the governing principles, the planetesimal hypothesis was gradually molded into the form in which it appeared in 1904 in Year Book No. 3 of the Carnegie Institution. When it appeared somewhat further elaborated for textbook use in Chamberlin and Salisbury's "Geology," Volume II, at the beginning of 1906 and in Moulton's "Introduction to Astronomy" in the same year, the planetesimal hypothesis for the origin of the solar system was fully launched on its career.

At that time spiral nebulæ played an important part in the planetesimal hypothesis. Known then to be the dominant nebulæ of the heavens, it was at first thought that they might represent huge solar systems in the making. Their characteristic large central mass, from which two arms of scattered haze, studded with large and small knots of matter, curved spirally outward on opposite sides, seemed just what an embryo solar system ought to be according to the planetesimal hypothesis. The central mass seemingly would become the sun; the larger knots of matter in the arms would become planets by gathering in the innumerable planetesimals constituting the general haze, while the smaller knots would give rise to satellites and planetoids. Diagrams showed how a star passing close to our sun would cause the development of a nebula of this spiral form, but it was explicitly stated that the planetesimal hypothesis was in no way dependent on the spiral form or upon the nature of the great spiral nebulæ revealed by the telescopes. The only essential feature was that the passing star pulls less than one per cent of the matter of the sun into elliptical orbits around it.

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[37] Idem.

[38] "On a Possible Function of Disruptive Approach in the Formation of Meteorites, Comets and Nebulæ." Astrophys. Jour., Vol. XIV (1901), pp. 17-40 and Jour. of Geol., Vol. IX (1901), 369-92.

This was the stem hypothesis; from it the peculiar conditions of any individual case might cause a solar system to evolve in accordance with any one of a considerable number of sub-hypotheses, all of them species of the same genus. Much time, in fact, was given to testing out various alternative sub-hypotheses. When, some years later, further researches with larger telescopes showed the spiral nebulæ of the heavens to be vast independent galaxies of stars beyond the limits of our own galaxy, the planetesimal hypothesis was in no way adversely affected by this advance of knowledge. In fact, the supreme advantage of the planetesimal hypothesis lies in having opened an entirely new field, wide and fertile in possibilities, and from which in all probabilty the true explanation of the solar system either has sprung or will spring. It may be that some other of the sub-hypotheses will be found to work out better, as knowledge develops, than the particular one to which the authors have given preference. But as yet their selection seems best.

## CHAMBERLIN AND SALISBURY'S "GEOLOGY"

Chamberlin's chosen lines of research had led him into steadily widening fields and these he was now plowing deeply. The planetesimal hypothesis provided for an earth with inherited characters quite unlike those previously postulated. Not only did the new view assign to it double parentage, instead of only one parent, but gave it also very different environmental conditions during the formative stages of its youth when its characteristics were being established. Naturally the better-known eras of its later life were but the outgrowth of the juvenile earth and were to be interpreted in accordance with its antecedents. A new geologic philosophy therefore sprang from the planetesimal hypothesis, and its far-reaching ramifications were to occupy Chamberlin throughout the rest of his life.

The development of these new lines was an important feature of the Chamberlin and Salisbury "Geology" whose three volumes came out between 1904 and 1906. The publishing house of Henry Holt and Company had sought this textbook for their American Science Series some time before the planetesimal hypothesis appeared, and the text was already under way in 1900. But as the new cosmogony unfolded and many geologic innovations were found to spring from it, the authors set themselves the task of bringing out a comprehensive textbook of geology developed along the new lines.

Volume I treated geologic processes to which Salisbury contributed most largely on erosion and deposition, and Chamberlin most largely on diastrophism, vulcanism, and the origin and descent of rocks.

Volumes II and III gave the history of the earth. Chamberlin portrayed in the first two chapters the origin of the solar system and the early stages of the earth, sketching in parallel fashion the development of the earth to maturity, first as had been taught in accordance with the Laplacian hypothesis and then as logically developed from the planetesimal hypothesis. It was characteristic of the spirit and method of the two authors that they made every effort to amend the molten-globe story so as to accord better with recognized geologic facts, but seemingly with little success. The planetesimal evolution was then traced through the initial volcanic, atmospheric, hydrospheric, and life stages to the recognized Archeozoic era. These stages involved new conceptions of the cause of vulcanism, of the origin of the atmosphere, of the origin of continents and ocean basins, of megadiastrophism, and of the inception of life on the globe. The departure from earlier views was revolutionary in the highest degree, but so defective did the time-honored interpretations seem to the author that the new basis was formally adopted and the Laplacian hypothesis and its consequences were given no further consideration in the unfolding of the earth's later history.

From the Cambrian period onward Salisbury was primarily responsible for the physical evolution and Chamberlin for the biological evolution. Paleontology is remote from cosmogony, but for the treatment of the faunas and floras recorded in the geologic strata Chamberlin was quite well prepared. The Wisconsin Survey while he was state geologist had done much paleontological work, and his early diagnosis of the Niagaran coral reefs even to this day excites the admiration of those who give attention to these peculiar structures. He had also published, in 1898, "A Systematic Source of Evolution of Provincial Faunas," and in 1900, "On the Habitat of the Early Vertebrates."

In the former publication he pointed out the fact that earth readjustments which cause the emergence of continents and the withdrawal of marine waters into the ocean basins are periodic (or episodic) in their occurrence, and that these periods of activity are separated by long intervening stages of relative quiescence during which lands are lowered by erosion and shallow seas are gradually spread over the continental platforms. During such a time of extended "epicontinental seas," as he termed them, the conditions for what he designated the "expansional evolution" of shallow-water marine life are signally favorable. Later, after long-continued baseleveling and expansional evolution of marine life, diastrophism causes the withdrawal of the marine waters from the continental platforms, leaving around each only a narrow, rapidly shelving shore-tract between the land and the abysmal slopes. The shallow-water fauna is compelled to follow the retiring sea and to crowd itself into this restricted zone.

"The new conditions will be in many respects uncongenial, for the streams will be rejuvenated and the amount of land wash will be greatly increased. Those species whose existence is dependent upon clear seas will be in imminent danger of extinction. Certain species to which these conditions are congenial may on the other hand be favored, but the grand result must necessarily be the destruction of the larger part of the previous expansional fauna and the forced adaptation of the remainder to new, and on the whole sterile and hostile conditions. A stage of general repressional evolution is thereby inaugurated and, in a comparatively short period, it is safe to assume, all or nearly all preceding species will have passed out of existence and new species, in a much more limited number but better adapted to the new conditions, will have been introduced." [39]

As a result of warping, the continental platform is likely to be bordered by various embayments favorable to life, separated from one another by narrow shore tracts which largely prevent free migration of shallow-water life. Each embayment will therefore develop its fauna in measurable independence and each will become the generating area of a provincial fauna. If a time of quiescence and baseleveling now ensues, these embayments will grow into extensive gulfs and, as they join in a general epicontinental sea, the commingling of their expanding faunas may result in a new cosmopolitan assemblage. These principles entered notably into Chamberlin's discussion of the Silurian and Devonian faunas in Volume II of the textbook.

The textbook also echoed and built upon Chamberlin's classic "Habitat of the Early Vertebrates." In a few pages of effective flowing language he had portrayed the appearance of the fishes, the first known vertebrates, as one of the most abrupt and dramatic in the life history of the earth, and had proceeded to show in simple fashion, as if the whole story had been revealed to him, how perfectly the known facts fitted together to indicate that the earth's vertebrate animals had their beginning not in the waters of the ocean, as generally had been supposed, but in running waters on land.[40] The geological facts bearing on the problem were not so much marshalled in argumentative support of a thesis to be established as they were unfolded in proper succession, along with zoological observations, to give a clear picture which invited acceptance through its own inherent probability and remarkable harmony throughout.

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[39] Journal of Geology. Vol. VI (1898), pp. 604-05.

[40] "On the Habitat of the Early Vertebrates." Jour. of Geol., Vol. VIII (1900), pp. 400-412.

In flowing water, an animal must maintain its position against the current either by a contract of some resisting kind with the bottom of the stream, or by an effective mode of propulsion competent to meet the constant force of the current without undue draft on its vital resources. Otherwise it would be swept out to sea and its race would be ended as a stream-dweller. It is different with ocean currents, for they return upon themselves and an animal may yield to them without losing its marine habitat; moreover, they are usually much feebler than river currents.

"A compact form of body presents obvious advantages, except as environment or food or locomotion requires some departure from it, and the vast majority of animals are more or less rotund, and their locomotive devices are adjusted to this form. But the rotund form offers much resistance to rapid currents and unfits the animal for effective stream life unless it persistently hugs the bottom. Neither the rotund floaters and swimmers like the ancient cephalopods, nor the cilliated sprawn of the sessile forms are well adapted to resist the unceasing pressure of a rapid stream, and these are practically absent from river faunas.

"There is only one conspicuous type that is facilely suited to free life, independent of the bottom, in swift streams, and that is the fish-form. The form and the motion of the typical fish are a close imitation of the form and motion of wisps of water-grass passively shaped and gracefully waved by the pulsations of the current. The rhythmical undulations of the lamprey which perhaps best illustrates the primitive vertebrate form, and is itself archaic in structure, are an almost perfect embodiment in the active voice of the passive undulations of ropes of river confervæ. The movement of the fish is produced by alternate rhythmical contractions of the side muscles, by which the pressure of the fish's body is brought to bear in successive waves against the water of the incurved sections. In the movement of a rope of vegetation in a pulsating current, it is the pressure of the pulses of water against the sides of the rope that give the incurvations. The two phenomena are natural reciprocals in the active and passive voices.

"The development in the fish of a rhythmical system of motion responsive to the rhythm impressed upon it by its persistent environment and duly adjusted to it in pulse and force, is a natural mode of neutralizing the current force and securing stability of position or motion against the current, as desired. Beyond question the form and the movement of the typical fish are admirably adapted to motion in static water and that has been thought a sufficient reason for the evolution of the form, and so possibly it may be, but fishes in static water have not as uniformly retained the attenuated spindle-like form and the extreme lateral flexibility as have those of running water. Among these latter it is rare that any great departure from the typical 'lines' and from ample flexibility has taken place, while it is not uncommon in sea fishes. Among the latter not a few have lost both the typical form and the flexibility. The porcupine-fish, the sea-horse, the flounders, and many others are examples of such retrogressive evolution, which is doubtless advantageous to them within their special spheres in quiet waters, but would quite unfit them for life in a swift stream. And if the view be extended to include the low degenerate forms, like the Ascidians, that are by some authors classed as chordates, the statement finds further emphasis.

"It is not difficult for the imagination to picture a lowly aggregate of animal cells, still plastic and indeterminate in organization, brought under the influence of a persistent current and caused to develop into determinate organization under its control, and hence to acquire, as its essential features, a spindle-like form, a lateral flexibility, and a set of longitudinal side-muscles adapted to rhythmical contraction, since these are but expressions of conformity and responsiveness to the shape and movement normally impressed by the controlling environment upon plastic bodies immersed in it. The necessity for a stiffened axial tract to resist the longitudinal contractions of the side muscles and thus to prevent shortening without seriously interfering with lateral flexibility, is obvious and is supplied by a notochord. Thus, by hypothesis, the primitive chordate form may be regarded as specific response to the special environment that dominated the evolution of a previously indeterminate ancestral form.

"In this larger application of the interpretation herein suggested, the chordate phylum is made to be essentially from first to last a terrestrial race, whose main habitat was the land waters and the land itself, though still a race that sent its offshoots down to sea from time to time from the mid-Paleozoic onwards."

These five paragraphs constitute the most hypothetical portion of the article, and that the hypothetical element was large was duly recognized by Chamberlin who was careful to state that the problem at that time admitted of no other than hypothetical treatment. Thirty years have since lapsed and the problem is essentially where Chamberlin left it. But the original article and the textbook exemplification of it have been notable contributions to one of the big problems of the evolution of living forms.

The textbook was the fruition of many years of research and teaching experience. Both authors were teachers of exceptional power and effectiveness. Chamberlin used the Socratic method in earlier years and with the occasional undergraduate class which he continued to teach nearly to the appearance of the textbooks; his later classes were exclusively graduate and to these he lectured, with an impressive command of the subject matter, upon the principles and theories of geology. Salisbury followed the Socratic method almost exclusively, and was recognized as one of the most outstanding teachers in the University. He was nearly at his best when the textbooks appeared. So the three-volume "Geology" served to extend widely the classroom spirit and intellectual methods of its authors, and through these, as well as by the great original contributions within its pages, it helped notably to mould American geologic thought.

## THE MISSION TO CHINA

With that far-reaching vision which characterized so many of his benevolences, Mr. John D. Rockefeller conceived the idea of doing something worthwhile for the Chinese people. A sum, adequate for a commission to visit China, reconnoiter the ground, and prepare recommendations, was entrusted to the University of Chicago. The University's choice of commissioners to conduct this survey of China and its needs fell upon

Ernest D. Burton and T. C. Chamberlin—two men selected from widely different spheres of thought to combine their humanistic and scientific experience in a balanced team. Horace G. Reed and Rollin T. Chamberlin were appointed assistants. Professor Burton and his assistant encircled the globe traveling eastward and studying conditions in India en route, while the Chamberlins, to bring a different point of view, went westward, the whole party assembling in Shanghai at the beginning of February, 1909. For nearly five months thereafter the commission traversed China by rail, river boats, sedan chairs, and Peking carts, studying fifteen of the eighteen provinces of China proper and making short excursions into Mongolia and Manchuria.

Chamberlin was profoundly impressed by the industry, thrift, and practical good sense of the Chinese people, who, in spite of strange superstitions and weak civic and nationalistic spirit, have steadily maintained their civilization for forty centuries during which many an oriental and western civilization has budded, flowered, and gone into decay. Entering into the project in hand with great enthusiasm, many a day on the march and after dark before the flickering flame of a tiny nut-oil lamp in some rustic Chinese inn, he unfolded to his companions the dreams and plans which came to his fertile mind. He drew lines for railroads, visioned in detail more scientific utilization of natural resources, mineral and agricultural, grappled with the application of western medical practice and research to the conservation of human life, and thrashed over the many possible ways of blending eastern and western educational methods and institutions so as to yield the best prospective results in the Chinese environment. His idea throughout was to graft, as far as possible, improvements and innovations on what already existed and to plant anew as little as possible, thus avoiding the semblance of revolutionary changes.

The commission visited the various viceroys and other high government officials to discover their general attitude toward foreign cooperation, sought their opinions and suggestions, and established good working relations with Chinese officialdom. Government schools were carefully investigated. The foreign mission schools and missionaries contributed, on their side, the practical experience and conclusions growing out of many years of work and struggle with Chinese problems. Chinese and foreign views were quite diverse, but together they disclosed fairly the needs and opportunities, the strong and the weak sides of the Chinese people and institutions, and the desirable and undesirable forces and tendencies then in operation in China.

But Chamberlin was too highly original a man to rely principally on the opinions of others when given carte blanche to make recommendations for something new of large proportions whose potential possibilities depended in considerable part on the judgment and constructive ideas of the commission. The commissioners must see China with their own eyes and in the final analysis build chiefly on their own observations.

Their climacteric excursion was up the Yangtze Kiang into far western China to the borders of the great mountains which buttress Tibet on the east. For thirty-nine nights, going and coming, Chamberlin slept afloat this great river and its tributary, the Min, mostly in native house-boats. The stupendous gorges above Ichang, where the river has cut through a folded mountain range, claimed a full week on the up journey in spite of favorable winds and a bonus to the boatmen for their best speed. Exposure of the whole Paleozoic stratigraphic section of central China in the canyon walls, with glacial tillite at the base of the Cambrian system, however, compensated the geologist for this enforced vacation from educational investigation.

Subsequently, four hundred miles in fourteen days across the Red Basin of Szechuan in sedan chairs took the commission through one of the loveliest garden spots on the face of the globe. Though sixty-five years of age, Chamberlin did much of this on foot for more intimate contact with the country and the people. The marvelous terracing of the hillsides, the intensive cultivation of the soil with utilization of plant reciprocities to secure the simultaneous cooperation of plants well fitted to one another so as to yield the farmer three to five crops a year, the simple but clever inventions of the Chinese, and the never-failing picturesqueness of the daily scenes, were a constant source of delight to him. Here was an old civilization unaffected by influences from without. Its inherent strength was plainly manifest, yet disease was rampant and dread epidemics swept away droves of people from time to time. In sanitation and in medical practice these people were still in the Dark Ages. The prompt cures by even such simple antiseptics as the members of the commission applied to the festering wounds and sores of several of their chair-bearers and boatmen astonished the natives. The white man's magic was plainly needed.

The commission eventually submitted a report of 977 pages covering the general outlook, the educational needs and the opportunities for large philanthropic work in China. The outcome of the report was a decision to concentrate effort in the field of medical science. The splendid Peking Union Medical College of the Rockefeller Foundation is now the tangible expression of this decision.

Their mission in China accomplished, the Chamberlins entrained at Mukden for Moscow in June, 1909. Ten days on the trans-Siberian train gave a much-needed rest, but the months of primitive travel and poor food had taken their toll. The first symptoms of serious stomach trouble, which was to afflict Chamberlin from time to time through the remainder of his life, now appeared. Slowly forming cataracts had already commenced to dim and blur his vision. A projected trip into Turkestan had to be abandoned, but father and son then zigzagged over much of Europe from the North Cape of Norway to Italy, Hungary and Roumania on the south, and from the Urals to the Atlantic, crossing as many of the mountain ranges as they could for a general picture of the orography and tectonics of Europe.

The expedition to China marked the final stage of Chamberlin's active field work. Well over six feet in height, of large frame which carried more than two hundred pounds, he was powerful physically, and the vigor which he displayed in tramping the paved paths of China seemed to show that he had lost little of his physical prowess with the advance in years. He felt fit and thought little of fatigue. But the break in health which began unexpectedly on the return across Siberia with stomach ulceration and severe attacks of sciatica, gradually grew worse and at several times during the next three or four years his condition occasioned alarm. Eventually skillful treatment prevailed and during the last fifteen years of his life his health slowly improved except for steadily failing eyesight.

## PHILOSOPHY OF CORRELATION

Our knowledge of the history of the earth has grown gradually by fitting together the local histories of small areas studied in detail, but as yet the general story is very incomplete. Most crucial and also most difficult has been the correlation of events in widely separated regions. An early advance in working method was the division of time into geologic periods based on major events of the earth's history. As the underlying reasons and basis for the division into geologic periods came to be better understood, the classification and correlation of events took on a new meaning. In 1874, J. S. Newberry had recognized the fact that the transgressions of oceanic waters on the continents and the resulting marine sedimentary accumulations have been cyclical in nature. In Volume I of the Geology of Wisconsin (1883) Chamberlin defined the typical geologic period to provide background for his treatment of the Paleozoic systems of Wisconsin, and presented a clear picture of the sequence of events which normally occurs during a period. "Ideally there might be said to be three main epochs in each period: (1) that of advancing waters and coarse detrital deposits; (2) that of deep waters and limestone deposits; and (3) that of retiring waters and mixed shaly deposits; but practically such ideal symmetry is usually broken by minor oscillations and irregularities of movement." [41]

Fifteen years later he took up the philosophy of correlation in the first of a long series of fundamental studies.

"The most vital problem before the general geologist today is the question whether the earth's history is naturally divided into periodic phases of world-wide prevalence, or whether it is but an aggregation of local events dependent upon local conditions uncontrolled by overmastering agencies of universal dominance. That there were no universal breaks in sedimentation or in the fundamental continuity of life is not only admitted but affirmed without hesitation . . . If, therefore, we seek for absolute divisions we doubtless seek in vain. But this does not dismiss the question whether the continuity of physical and vital action proceeded by heterogeneous impulses or by correlated pulsations. If the latter, then the history of the earth, when deciphered, will assume a rhythmical periodicity susceptible of natural classification and of significant and rational nomenclature; if the former, the contradictory phases of local actions will inhibit all but the most general unity and render classification and nomenclature either arbitrary or provincial." [42]

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[41] Geology of Wisconsin. Vol. I (1883), p. 210.

Chamberlin believed that the evidence strongly favored periodicity of the larger movements. The major movements of the earth's surface seemed to him to have been the sinking of the ocean bottoms and the withdrawal of the shallow epicontinental seas into the deepened basins. A case for the sinking was found in the force of gravity operating on the material of the earth's interior to produce rearrangement in more compact form. Quite different this was from the prevalent idea of contraction of the earth due to cooling from a molten condition. In the general process of rearrangement of matter in favor of greater density, the oceanic segments, being larger and of heavier material, sank most and the smaller and lighter continental segments sank less, thus increasing the topographic relief between the ocean basins and the continental protuberances. In the downcrowding process, the weaker, lighter continental segments were squeezed between the stronger, heavier oceanic segments and their borders in particular were wrinkled into mountain ranges.

Emergence and deformation of the continents in this manner take place with relative rapidity apparently when gradually accumulating stresses finally reach the yielding point of the materials. Then accompanying withdrawal of the shallow seas interrupts the marine stratigraphic record. Land areas become extensive and locally the topographic relief is high. Climates become diversified and plants and animals are subject to the stress of changed environmental conditions. The whole combination of interrelated events is a diastrophic revolution involving and affecting geologic and biologic processes to an exceptional degree. An old period has been brought to an end and a new one begins.

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[42] The Ulterior Basis of Time Divisions and the Classification of Geologic History. Jour. of Geol., Vol. VI (1898), pp. 449-50.

Erosive processes now attack the rejuvenated lands with maximum vigor and in time reduce them to lowlands and extensive sea-level plains. Sands and muds carried to the ocean displace their volume of sea water. Sea level rises and shallow waters advance widely upon the bevelled land surfaces. Extensive sedimentary deposits accumulate on the continents constituting a geologic rock system. Climates are mild and life in general thrives. Such conditions develop slowly and continue for a long time. Eventually, growing stresses within the earth bring on another diastrophic revolution; the geologic period is ended, and another cycle is inaugurated.

So basic are these principles in fundamental geologic philosophy, that Chamberlin's own words may be repeated for further exemplification.[43]

> "I trust that many of you will agree that, in general, the relatively upward movements of diastrophism have been located continuously in the continents, and the broad downward movements continuously in the ocean basins, and that, setting aside incidental features, the dominant effect of the successive diastrophic movements has been to restore the capacity of the ocean basins and to rejuvenate the continents. This conclusion seems to me to be strongly supported by the general course of geologic history, wherein sea-transgressions and sea-withdrawals have constituted master features. Perhaps our firmest ground for this conviction is found in the present relations of the continents and the sea basins. If heterogeneity had dominated continental action in the great Tertiary diastrophisms, the results should stand clearly forth today. Some continents should show recent general emergence, while others should show simultaneous general

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[43] Diastrophism as the Ultimate Basis of Correlation. Jour. of Geol., Vol. XVII (1909), pp. 688-92.

submergence. The dominant processes today should be those of depressional progress, on the one hand, and those of ascensional progress, on the other. As a matter of fact, all the continents are strikingly alike in their general physiographic attitude toward the sea. They are all surrounded by a border-belt, overflowed by the sea to the nearly uniform depth of 100 fathoms. These submerged tracts are all crossed by channels, implying a recent emergent state. None of the continents is covered widely by recent marine deposits, and yet all show some measure of these. Wide recent transgressions in one part do not stand in contrast with great elevations in another. Even beyond what theory might lead us to expect, when we duly recognize the warping incidental to all adjustments, the recent relations of the continents to the seas conform to one type. The 10,000,000 square miles of continental margin, now submerged, is distributed around the borders of all the continents with a fair degree of equability. May we not, therefore, agree that in the world-wide phases of diastrophic movements, the basins have been additionally depressed and the continents repeatedly rejuvenated.

"It is important that we should agree, or agree to disagree, on one further point. Have diastrophic movements been in progress constantly, or at intervals only, with quiescent periods between? Are they perpetual or periodic? The latter view prevails, I think, among American geologists. This view has acquired special claims since base-leveling has come to play so large a part in our science, for it is clear that the doctrine of base-leveling is specifically inconsistent with the doctrine of perpetual deformation, for the very conditions prerequisite to the accomplishment of base-leveling involve a high degree of stability through a long period. The great base-levelings, and the great sea-transgressions, which I think are little more than alternative expressions for the same thing, have, as their fundamental assumption, a sufficient stability of the surface to permit base-leveling to accomplish its ends. Shall we not therefore agree that there has been periodicity in the world-warping deformations? Let this not be held with such exclusiveness that we fail to recognize duly the effects of the adjustment of minor stresses, at other times. These may be preliminary of after-effects of the larger movements, or they may be due to local stresses more or less independent of the general body-stresses. These quite certainly have been present, and have produced intercurrent departures from the strict tenor of the great systematic movements.

"Correlation by general diastrophic movements takes cognizance of four stages: (1) the stages of climacteric base-leveling and sea-transgression, (2) the stages of retreat which are the first stages of diastrophic movement after the quiescent period, (3) the stages of climacteric diastrophism and of greatest sea-retreat, and (4) the stages of early quiescence, progressive degradation, and sea-advance.

"(1) The characteristics of the climacteric stage of base-leveling and sea-transgression need little further characterization here, for the function of base-levels is known to all American geologists and the function of great sea-transgression to every stratigrapher and paleontologist. We have in base-leveling conjoined with sea-transgression, just that combination of agencies which is competent to develop the broad epicontinental seas of nearly uniform depth requisite for an expansional evolution of shallow-water life. At the same time, it furnishes for wide migrations and the comminglings that lead to cosmopolitan faunas of the shallow-water type.

"(2) The stages of initial diastrophism and sea-retreat find their criteria in the deposits that spring from an increased erosion of the deep soil-mantles accumulated in the base-level period, in the effects of increasing turbidity, in the lessening areas suitable for the shallow-water life, and in the limitation of migration.

"(3) The climacteric stages of diastrophism are marked by the stress of restrictional evolution among the shallow-water species; by increased clastic deposition in land basins, on low slopes, and on sea borders, by great land extension, but often, perhaps dominantly, by diversity of land surface and by liability to climatic severities and diversification. Arealy, land life is favored, but it is hampered by the climatic and topographic diversities, and these may prove graver obstacles to migration and intermingling than even the tongues of sea that previously traversed the land surface. Correlation by glaciation in these stages is likely to prove a valuable adjunct, but we must first test our criterion, for we are not as yet quite sure that contemporaneity of glaciation is inferred on reliable grounds. The shallow-water life of the diastrophic stages is driven into narrow border tracts and into local embayments, and is thus forced into special adaptations and into narrowly provincial aspects.

"(4) The early stages of quiescence and of base-leveling, with advancing seas, are peculiarly fruitful in biological criteria, for they are marked by re-expansions of the narrowly provincial shallow-water faunas of the previous stages. The progressive development of these provincial faunas and their successive unions with the faunas of neighboring provinces, as these come to coalesce by means of the progressive sea-advances, form one of the most fascinating chapters in life evolution, and give some of the most delicate of criteria for correlation.

"We are accustomed to look to the life record as our chief means of correlation. Its very high utility is quite beyond discussion. Thoughtful students, however, recognize that the paleontological record is based, in an essential way, on stratigraphy and that it is corrected and authenticated by the precise place the life is found to occupy in the stratigraphical succession. Stratigraphy and paleontology thus go hand in hand, each sanctioning the other. *Diastrophism lies back of both and furnishes the conditions on which they depend.*"

Hence Chamberlin's dictum: Diastrophism is the ultimate basis of classification and correlation.

## THE ORIGIN OF LIFE

A radically new story of the parentage and birth of the earth having appeared in the planetesimal hypothesis, a new interpretation of its juvenile and mature activities was required. To this and to the working out of a comprehensive geologic philosophy on the new lines, Chamberlin devoted his later years. The newly opened leads naturally carried him into many different fields, one of which was the beginning of life on the earth.

An earth built up by accretion of planetesimals naturally presented very different surface conditions from one solidifying from a molten state. Instead of being entirely of crystalline igneous rock, the surface material of the youthful earth on the new basis was in part igneous, in part sedimentary and in part a heterogeneous assemblage of planetesimal matter of composition not radically different from that of the meteorites falling in today. This was the starting point. Rather opportunely an investigation of the gases obtained from heating meteorites in vacuo made during a larger study of the gases in rocks,[44] brought forth some facts seemingly of much significance. Meteorites were known to contain carbides, nitrides, sulphides, phosphides, and hydrocarbons, and it was noted both that these peculiar compounds are unstable on the surface of the earth, and that they include the particular elements which comprise living tissue and are essential to life. Furthermore, these unstable compounds of the elements essential for life were, according to the planetesimal hypothesis, commonly intergrown, or otherwise closely associated with one another, so that the products of any reactions that might grow out of their instability would be favorably located for reaction upon one another. Particularly significant, therefore, was the close intergrowth of these compounds of the organic elements in states of combination which, while stable in the cosmic regions surrounding the earth from which the planetesimal material was gathered, were pronouncedly unstable in the presence of air and water, even at the ordinary temperatures at which organic synthesis takes place. On the earth these compounds would inevitably have participated in chemical reactions giving rise to other combinations of the elements critical to biologic activity.[45]

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[44] Rollin T. Chamberlin, The Gases in Rocks. Publication No. 106, Carnegie Institution of Washington (1908), p. 80.

With his characteristic thoroughness of treatment of problems, Chamberlin proceeded to analyze the environmental conditions that would have favored organic synthesis on the youthful earth. The open ocean seemed to him unfavorable for the start of life, for there diffusion and dilution of the products of reactions would prevail. But on the other hand, the porous mantle of the land areas, supplied by planetesimal infall with unstable carbides, nitrides, phosphides, and sulphides steadily undergoing transformation into more stable compounds and generating during this process hydrocarbons, ammonia, hydrogen phosphide and hydrogen sulphide gases mingled with the ordinary gases carried by the planetesimals, furnished exceptional opportunities for interactions and combinations.

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[45] T. C. Chamberlin and R. T. Chamberlin, Early Terrestrial Conditions that may have favored Organic Synthesis. Science, Vol. XXVIII (1908), pp. 897-911.

For specific illustration, Chamberlin selected a porous soil mantle situated alongside of a permanent body of water of appropriate salinity. In such an environment he envisioned many natural processes likely to cooperate in synthetic activity. Among these were percolation of water conditioned by a fluctuating water table due to accessions and evaporation, capillary action, osmosis, catalytic action, polymerization and other possible activities. Possible rôles which might be played by these were portrayed tentatively to deploy the problems in detail, but with constant reminders that nothing more than hypothetical suggestion was in mind.

What was attempted, however, was to indicate that in the early stages of the earth's development, according to the planetesimal hypothesis, the appropriate chemical elements, predisposed to enter into new combinations, were brought together in environments and under conditions singularly favorable for organic synthesis in the direction of primitive life. It was shown also that later, when planetesimal infall slackened, the opportunities for inception of life in this manner were greatly reduced. Chamberlin believed that the geologist's proper contribution to the problem of life beginnings on the earth was to handle the available stage settings for the start of the life story. This seemed to be accomplished by presenting a combination of inorganic processes operating on the necessary materials under conditions of such exceptional nature that they might have led into the realm of the organic. But to supply the vital spark of life which actually started the drama of life and kept it going falls naturally into the province of the biologist or the bio-chemist.

## THE ORIGIN OF THE EARTH

When the planetesimal hypothesis was about fifteen years old and had become widely known from the textbooks and technical articles by its two authors, Chamberlin yielded to the request for a less technical presentation of the hypothesis in book form. The outcome was his little book, "The Origin of the Earth," which was published in 1916. To tell the story simply but well was his endeavor. For a better understanding and a more intimate contact, he took his readers into his workshop to show them the tools with which he had worked, and how, step by step, the investigation had been carried on. By relating how some efforts had proved futile and how various paths had led to no useful results he revealed the fullness of his explorations, unproductive as well as productive, and the persistency of his search for the truth.

"The Origin of the Earth" typifies Chamberlin's manner of unfolding a theme to the serious lay reader. The treatment throughout is direct and forceful, but the wealth of ideas and the rich literary style make the book far from light reading for either the scientific or the linguistic student. The reader must take it at its own level, for the author never allowed himself to lower his standards, though he simplified as much as possible by avoiding technical terminology.

The evolution of the planetary system and the juvenile shaping of the earth and its reorganization may be considered the key topics of the volume. The first is the planetesimal hypothesis, already considered; the others are the earth's growth and youthful development, worked out in accordance with that hypothesis and the state of geologic knowledge at the time. The infall of planetesimals, the holding of an atmosphere close about the young earth, and the gathering of its primitive waters into its surface hollows were the three concurrent activities which gave direction to the planet's growth and thus dominated its later career. The cooperation of this triumvirate—the lithosphere, hydrosphere and atmosphere—in the progressive shaping of the earth's surface is an intricate story partly told in this book but more fully developed in later publications.[46]

Changes in the rate of rotation, as the planet grew by adding to itself the planetesimals, set up stresses which analysis seemed

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[46] Study of Fundamental Problems of Geology: The Growth of the Earth. Carnegie Institution of Washington, Yearbook No. 25 (1926), pp. 372-87.

to show might lead to a primary segmentation of the earth body. Modifying atmospheric and hydrospheric influences also came into play. The finer and lighter planetesimal materials floated longest in the atmosphere and were brought down by rain and snow especially in the regions of greatest precipitation. These being dominantly the land areas, judged by analogy with present precipitation, such areas gradually came to be built up of materials slightly less in specific gravity than those falling on the water areas. Slight though these differences in specific gravity were, they were perpetuated and increased by selective action of the hydrosphere. The lands suffered weathering and wash, and the dissolved portions were added to the oceans, either to remain in solution in their waters, or to be deposited on their bottoms. The residual material left on land was richer in silica and aluminum and consequently of lower specific gravity than the more soluble compounds of calcium, magnesium, sodium, and potassium which found their way to the sea. Small as were the differences in density thus brought about, the separating processes were long in operation during the later growing stages of the earth, and tended to develop sub-oceanic segments of greater density than continental segments. Reorganization of the material, local liquefaction, and magmatic segregation proceeded in their appropriate ways in the natural course of events. In subsequent deformations of the globe the heavier oceanic segments were especially prone to sinking, thus accentuating the ocean basins and leaving the lighter continental segments standing progressively higher and more sharply differentiated. In this way the foundations were prepared for the ensuing geologic story.

## DIASTROPHISM AND THE FORMATIVE PROCESSES

The autumnal years of Chamberlin's life were given in considerable part to gathering in some of the slowly ripening fruits of the planetesimal hypothesis. The most systematic harvesting consisted of a series of fifteen articles under the heading, "Diastrophism and the Formative Processes," which appeared in the *Journal of Geology* between 1913 and 1921. The planetesimal cosmogony had opened the way for the evolution of an elastico-solid earth, though it did not exclude the possibility of a molten earth or even the probability that molten and gaseous states may dominate planets much more massive than the earth. "The long, slow growth of the main mass of the planet offers rather strong presumption of a relatively cool, solid accretion attended by heterogeneities of composition and differentiations of accession and crystalline organization that were never smoothed out by liquefaction, but have remained of the same type as those now presented by the earth." The concept of an elastico-solid earth implied an organization and subsequent development very different from that of the liquid globe based on the Laplacian hypothesis. To Chamberlin this concept seemed to avoid many embarrassing difficulties with which he had struggled for years and, as he tested the different possibilities, it was gratifying to find that the new lines grew increasingly fruitful in leading to further discoveries.

Shrinkage of a cooling earth had been found to be inadequate to produce the surface corrugations observed in the many belts of mountain folding. And yet, following the molten globe hypothesis, about all the shrinkage left to be registered in the rocks would have been the meager amount that might have resulted from cooling for, with the passage of the earth substance from the assigned gaseous to the liquid state and thence at length to the solidifying state, a large part of all possible adaptation to the demands of pressure should have taken place before the record of disastrophism began. Furthermore, cooling would have been opposed by an embarrassing supply of heat from radioactive processes.

On the other hand, an earth built up slowly by the accession of solid particles would have retained very nearly its maximum resources of combination, adjustment, and compression. Such an earth was potentially capable of great compacting and consequent deformation. Chamberlin sought the probable order of magnitude of the shrinkage of the earth by comparing our planet with neighboring members of the solar system. The moon, whose mean radius is 1080 miles, has an average specific gravity of 3.34; Mars, whose radius is 2170 miles, has a specific gravity of 3.58; Venus, whose radius is 3851 miles, a specific gravtiy of about 4.85; and the earth, whose radius is 3959 miles, a specific gravity of 5.53. If these four bodies were built up by the ingathering of planetesimal material of essentially the same density, and if the progressive increase of density with increasing size of the body be the result of greater compaction under greater pressures, the shrinkage in volume may readily be computed. Chamberlin found that an earth built up of moon material of density 3.34, if changed to the earth's density of 5.53 by rearrangement of matter under pressure, would have undergone a circumferential reduction of 4555 miles, corresponding to a radial shortening of 725 miles. Perhaps more surprising was the fact that in changing from the size and density of Venus, a stage in which 80 per cent of the growth of the earth had already been attained, to that of the present earth a circumferential shrinkage of 1112 miles would have resulted. Apparently it might reasonably be concluded that the rate of shrinkage per unit increase of mass was greatest in the final stages of the earth's growth.

Although some of the greater density of the earth may have been due to heavier planetesimal material than that which went into the moon and the other planets,[47] the amount of shrinkage deduced was so great as to appear ample for all the crustal shortening implied in the contorted rock formations. The planetesimal earth thus possessed adequate potentialities for crustal deformation. A basis for diastrophism was thereby provided though Chamberlin left the specific activities and modes of concentration for more complete analysis in the concluding article of the series: "The Self-Compression of the Earth as a Problem of Energy."

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[47] Reasons, however, were advanced for thinking "that if the moon, Mars, Venus and the earth were built up normally by the planetesimal method, they should contain proportions of inherently heavy material in the inverse order of mass."

The series "Diastrophism and the Formative Processes" did not attempt a consecutive presentation of its author's philosophy of diastrophism. Many phases of that philosophy had been adequately presented before and some of them have already been considered briefly in this memoir. Rather was it a succession of critical essays on selected phases which Chamberlin wished to develop and extend beyond previous treatments. In particular, he gave much attention to the geologically significant interplay between diastrophism and the activities of the sea. The rejuvenation of the continents, their essential permanence as major relief features of the globe, the lateral stresses within the continental proturberances and their relations to continental creep and sea-transgression, the growth of the continental shelves, and the significance of the shelf-seas covering them, stood forth as subjects of prime consideration.

The geologic record shows that long periods of relative quiescence, during which the lands have been reduced to peneplains of wide expanse, have occurred from time to time. It is equally apparent that the base-leveling process cannot normally reach the stage of an advanced peneplain if continuous warping of the crust is in progress. On the contrary, the crust must hold an approximately static attitude long enough for the gradational processes to accomplish the results observed. The conclusion is clear that continental uplift has not been a continuous, steadily progressive process, but that it has recurred at such wide intervals as to permit in the meantime planation nearly to base-level with consequent evolution of shelf-seas and extensive inundations of the continental areas. All this seemed to Chamberlin to imply an elastic, rigid earth of sufficient strength to allow an accumulation of stress over a long period without notable yielding until, finally, easement of the stresses took place in a diastrophic revolution. The major diastrophic movements, according to the record, have been episodic in nature recurring between long periods of relative stability.

During times of stability, deposition of sediment on the outer slopes of the continental platforms built up continental shelves and extended them into the ocean basins. Chamberlin regarded

shelf-sea work as pre-eminently a process of terracing and the continents as pre-eminently the great terraces of the globe. Between the episodes of diastrophism the shelf-seas spread widely over the continents, extending the marine sedimentary deposits and affording opportunity for the evolution of shallow-water marine faunas. "The picture of the continents as essentially terraces wrought upon diastrophic embossments is no doubt the truest that can be found, and the contest between the diastrophic forces that emboss by protrusion and the gradational forces that terrace by planation and shelf-building, the chief physical battle of geologic history."

From the planetesimal hypothesis, followed logically through its natural chain of consequences under strict guidance from the testimony of the earth's past and present behavior, arose the foundations for a consistent, systematic interpretation of geologic history. Most fundamental was diastrophism for which the hypothesis afforded a ready cause and *modus operandi*, arising from the very nature of the postulated mode of the earth's growth. Chamberlin fitted in harmoniously the processes of vulcanism and made new contributions in that field. Cooperating with diastrophism in some ways and operating directly against it in others, the gradational processes played their appropriate part, as he brought out in masterly fashion. These in turn influenced earth climates in varying degree, and finally the whole combination, directly or indirectly, exerted a powerful control on the evolution of life.

The keynote of this series of articles was diastrophism in the large, for which Chamberlin coined the word, "megadiastrophism," to set it over the subsidiary manifestations of lesser magnitude ordinarily connoted by the term, "diastrophism." Few subjects have greater complexity or more ramifications, the mere enumeration of which reaches formidable proportions. To bring together some of the more essential developments and conclusions was Chamberlin's objective in the next to the last number of the sequence, which he called: "Groundwork for the Study of Megadiastrophism. Part I. Summary Statement of the Groundwork Already Laid." This was a succession of seventy-seven separately numbered propositions or paragraphs, each one of which reads like the abstract of an independent paper. A vast field was tilled in these seventy-seven furrows, which the plowman felt he had merely seeded for valuable crops to come in the future.

## THE TWO SOLAR FAMILIES

Chamberlin's last publication was his booklet "The Two Solar Families." This was started as a revision of "The Origin of the Earth" at the request of the University of Chicago Press. But he soon found that his ideas had developed so greatly since the appearance of the earlier volume that two books would be required to cover the ground at all adequately. In the first he proposed to delineate the origin of the solar system, and in the second to present the growth of the earth. The first he completed; the second remains unfinished.

"The Two Solar Families" is the story of the sun's children. In an introduction, scarcely surpassed for beauty in the whole realm of scientific writing, we are told that the progeny of the sun belong to two families—the Planetary Family, embracing the planets, planetoids, and satellites, and the Cometary Family, comprising the comets, chondrulites, and meteorites. One parent was common to both families; the other was the chief differentiating factor. A passing star, the planetary family's stellar father, called forth larger masses of sun substance than the sun was accustomed to give forth at other times and gave the planetary offspring relatively robust constitutions and orderly habits of behavior. The cometary family came from feebler cooperation on the part of the starry host outside the solar system and fell heir to too much of the turbulence and the fiery antagonisms of the sun, and to too little of the steadying orbital energies of the starry group outside. "The planets, planetoids and satellites are plain plodding children compared with the comets, the meteors, and the meteorites. But the lives of the latter seem to be as notably short as they are spectacular and reckless in the wastage of their energies, while the lives of the former seem likely to be as long as they are modest, steady, and exemplary in the husbanding of their energies."

Among the changes in point of view from the earlier volume it is to be noted that the planetesimal hypothesis has become entirely divorced from the spiral nebulae which at one time had seemed to show family relationship. Much more important have become the spheres of activity, or spheres of control, of the sun and the individual planets, embracing both spheres of gravitative control and spheres of effective light pressure. The relative strengths of the pull of gravity and the push of light and other repellent forces of the sun distinguish the dynamic zones of the solar system. For small, light particles near the sun the repulsive forces overmatch the sun's gravitation and drive such particles away from the sun. Chamberlin saw in this a possible explanation for the striking fact that the four inner planets have grown less and are of higher specific gravity than the outer planets. He differentiated four dynamic zones concentric around the sun. The inner two he described as follows:

"I. The first constitutes the inner environment of the sun. It embraces the orbits of the small, naked or slightly clothed planets, Mercury, Venus, Earth, Mars, and the planetoids. The repellent agencies effectively drive out of this zone free molecules and fine dust, except as they are held by the superior attractions of Venus, Earth, and Mars. Comet's heads suffer wastage and depletion while traversing this zone. Tail-stuff is developed from comet heads and driven out of this zone with great velocity. At the same time it seems to have been possible for small planets, planetoids, and satellites to assemble, to survive their 'perils of infancy,' to grow to their present states, and to give promise of living on to unknown lengths in spite of all solar repellency. These planetary bodies even seem to have thrived under conditions that were hostile to the comets.

"II. Outside this inner environment of the sun lies the zone of the great gaseous planets, Jupiter, Saturn, Uranus, and Neptune. In this zone the selective solar repellency seems to be much abated. There seems to be greater tolerance of gases, and there certainly was greater gaseous growth."

To accord with the observed natural division of the planets into two groups, an outer one of four large low-density planets and an inner one of four small high-density planets, Chamberlin suggested that the large outer planets arose from projectiles shot toward the passing star and that the smaller inner planets arose from projectiles shot in the opposite direction from the remote side of the sun. These two groups of four bolts each he supposed to represent the systematic response of the sun to the differential attraction of the star as it passed obliquely over the sun's two specially eruptive belts on either side of its equator. "It is assumed that there were two shots toward and two shots from the star in crossing each belt, making, in all, four great missiles sent far out past the star in its rear and four smaller missiles shot shorter distances from the opposite belts on the far side of the sun. We thus postulate only four main double shots. The planetoids are supposed to have arisen from small irregular projections stimulated on the far side of the sun by the passing star before it reached the specially eruptive equatorial belts." Chamberlin believed that there should have been counterpart eruptions of this irregular type from the side of the sun toward the star, and these he thought might possibly be represented by undiscovered bodies beyond Neptune. In fact, he introduced a diagram[48] which includes several lines of projection (with a question mark) for planetoids beyond the orbit of Neptune. As is well known, the planetoid Pluto, revolving far outside the orbit of Neptune, was discovered two years after his death.

The later pages of "The Two Solar Families" are filled with such a wealth of new contributions that nothing more than mere citations of a few lines of advance can be attempted here. A very careful analysis of the presumptive activities of the planetesimals brought out more concretely and completely than ever done before their probable behavior and showed how very naturally they may have occasioned the peculiarities observed in the different members of the solar system. Particularly suggestive is the chapter on the growth-creep of the axes of the planets in which it is shown that the impact of the planetesimals would shift the axis of rotation of a growing planet from the plane of projection of the solar outburst progressively toward a position at right angles to the plane of the solar system. The hitherto baffling inclination of the earth's axis, responsible so happily for our yearly seasons, thus apparently finds a very simple and plausible explanation. The searching analysis developed also possible explanations of the outstanding peculiarities of Mercury and Venus, the reason why the moon constantly presents the same face to the earth, and the reason for the opposing land and water hemispheres of the earth.

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[48] The Two Solar Families (1928), Fig. 28, p. 156.

Although the cometary family is characterized by loose organization, yet Chamberlin brought the chondrulites, comets, and meteorites together as related products of gaseous outbursts projected to the farthest reaches of the sun's sphere of control where inequalities in the attractions of the stars outside gave side-pulls sufficient to cause the assemblage of now solid particles to miss the sun on the return journey and to swing around it in greatly elongated ellipses. Condensations of the gaseous masses on their outward journey produced the tiny chondrulites characterized by radical and concentric structures like the hailstones in a storm cloud. The whole swarm of chondrulites constituted a comet; when the comet came back into the heated environs of the sun at perihelion occasional collisions between a few of the chondrulites resulted in welding a very small proportion of them together into chondrule aggregates, which are the meteorites. So inherently simple and natural is the whole picture that it has much to commend it though it is radically different from its author's earlier conception of the formation of comets and meteorites.

"The Two Solar Families" came from the press on Chamberlin's eighty-fifth birthday, September 25, 1928, and the first copy to be finished was hurried to him for a modest celebration in the afternoon. He planned to rest for a month and then to take up again the manuscript for the second volume, "The Growth of the Earth," on which considerable progress had already been made. But a month later he was ill. The splendid mechanism which had worked so long and so well was worn out. He was taken to the University hospital, but nothing in the power of his medical colleagues could restore his weakening heart, and he slipped away peacefully on a still further journey into the unknown, November the fifteenth.

## THE MAN HIMSELF

On the human side, Thomas Chrowder Chamberlin stood out nearly as distinctively as his works did in the field of science. Six feet one-and-a-half inches in height, of large, athletic build, he was a rugged and vigorous figure throughout most of his life. On the farm he had had a neighborhood reputation for pitching hay and for other occupations combining strength and skill; in college he excelled in sports, particularly football of the kind then being played. As a young geologist and administrator, his obvious physical strength and mental capacity, his open, friendly, sympathetic nature, and his marked abhorrence of all that was false and mean, led to his appointment to positions of greater and greater responsibility. As the years went by, his characteristic seriousness of mien, softened by a naturally kindly and serene facial expression came to give him an appearance of exceptional dignity. Later his dignity was enhanced by white hair and furrows of thought which gradually roughened his brow.

Most characteristic of the workings of Chamberlin's mind were his independence of thought and his intellectual integrity. In the bitter partisanship of the Civil War, he put in a good word, now and then, for the South. At the University of Wisconsin, whose previous presidents had been clergymen, he answered the sneering question: "Who will now preach the baccalaureate sermon?" by giving his own baccalaureate addresses, and so effectively as to create a profound impression by his originality of thought and his inspiring delivery. When satisfied that his policies were along the right lines, he was fearless in putting them into effect, though safely guided by a shrewd sense of what could be accomplished satisfactorily and what was inadvisable to attempt.

Intellectual honesty he placed highest, as was apparent in most of what he did. In all probability his consistent success in securing appropriations from the Wisconsin legislatures was due, in no small degree, to the confidence which he invariably inspired and to the transparent reasonableness of what he sought. Political sense he had, but he made little use of political ties and gave still less thought to personal popularity. In fact, as university president, he could scarcely be called popular in the ordinary meaning of the word, for he subordinated the personal and social aspects of his position to the carrying out of his ideas and the maintenance of his ideals in the administration and development of the University.

At the University of Chicago he was back again in the scientific work and environment most congenial to him. He brought together for the Department of Geology the strongest group which he could procure: Rollin D. Salisbury, in geographic geology; Joseph P. Iddings, in petrology; Richard A. F. Penrose, Jr., in economic geology; Charles R. Van Hise, as part-time professor of pre-Cambrian geology; Stuart Weller, in invertebrate paleontology; and, later, Samuel W. Williston, in vertebrate paleontology. In addition there were others on special appointments of shorter duration. This was indeed a remarkable assemblage of men who represented not only the best in their respective fields, but who were conspicuous also for exceptional personal qualities. Whenever the department came together in public it attracted attention; people commented on such a group of uniformly tall, handsome, dignified men. They reflected in a way the ideals of their leader, who was as thoughtful of superior manhood as of superior scientific ability and attainments. Likewise the associate editors of the *Journal of Geology,* selected from leading institutions in this country and abroad, were an imposing array of outstanding geologists. In the midst of such inspiring colleagues and associates, Chamberlin was in a position to do the best work of which he was capable.

During the first decade of the growth of the new University, Chamberlin taught some elementary courses as well as special graduate courses in glacial geology and the more advanced phases of general geology. His commanding personality, mastery of precise diction, and versatile fertility of mind, gave high cultural value to his undergraduate instruction. Though his contacts with the undergraduates were somewhat limited, whenever he did come in touch with them, they felt strongly his wholesome and stimulating influence.

But it was the graduate students who profited most from his lectures and the contact with him. For many years he gave a series of courses under the elastic title of "Principles and Theories of Geology." These ran through the whole gamut from cosmogony to the geology of the present and its implications for the future, and in the aggregate covered his entire geologic philosophy. Each year, completely ignoring the outline of the previous year, he presented his material afresh in accordance with his latest views and the newest developments. Thus it became quite customary for students to repeat the courses, for not only was a new slant commonly given to old problems, but many new problems were constantly coming to the fore. Cosmic geology, at the outset, and Pleistocene glacial geology, at the close, were naturally favorite fields for particularly thorough treatment; but outside of the more technical phases of paleontology and petrology, the whole geologic province came under his general survey. He elaborated the planetesimal hypothesis and traced with great care its bearing upon continental evolution, diastrophism, vulcanism, climatology, and the resulting biologic responses. All in all there arose a comprehensive geologic philosophy. But the prime object of these courses was not so much to present a consistent geologic philosophy as to develop the critical powers of the students in attacking new problems and thus to prepare them for their own researches. The chief emphasis was placed on sound, judicial thinking.

Setting an example was ever a vital part of Chamberlin's advanced teaching. He unfolded the steps of progress in many past researches and discussed critically his own and other current studies to bring out the objectives, difficulties in the way, and the means of overcoming them. Various students were utilized as helpers in the details of the larger studies, and thus they obtained first-hand acquaintance with his methods. In fact, the extraordinarily thorough drill in precise geologic thinking by Salisbury coupled with the inspiration for research from Chamberlin was in considerable measure responsible for the conspicuous success afterwards achieved by the impressive list of young geologists trained at Chicago when these two teachers were in their prime.

The quarter century 1892-1918 while Chamberlin was head of the Department of Geology at Chicago included his most productive years. In spite of multitudinous demands on his time, he was then engrossed primarily in his researches. Here lay his greatest interest; he took no vacations; research was play and any spare time was an opportunity not to be lost. But rarely did he drive himself; when in the mood he worked enthusiastically and effectively; when not in the mood for a particular problem, he read or attempted something else. While engaged on one of his books he once wrote fifty pages in one day, loafed the next, browsing in the library, and then wrote sixty-six pages on the following day. Though his large script filled pages quickly, the actual output of material was surprising in amount.

He wrote spontaneously and rapidly when handling new material, but such writings, fluent though they were, never reached the printer. They were rewritten and revised over and over again. It was amazing how much interlineation could be put on a page of seemingly satisfactory manuscript. Since his handwriting was peculiar and none too legible, the stenographer must have groaned under the constant slaughter of her copy. But he invariably kept at it until the final product satisfied his critical taste.

Somewhat similar was his habit of solving problems. With great fertility of imagination, he dreamed rapidly ahead along the various alternative lines of solution following the possible ramifications whithersoever they might lead. Later he cast aside the unpromising leads. Rejecting on the one hand what he termed the "method of colorless observation" as sterile, and on the other hand avoiding the "method of the ruling theory" as dangerous and likely to block the road to further advances, he believed that the true scientific method was to encompass the problem in all its aspects and to treat impartially the various factors and alternative possibilities. This he called the "method of multiple working hypotheses." [49]

> "Conscientiously followed, the method of the working hypothesis is an incalculable advance upon the method of the ruling theory, but it has some serious defects. One of these takes concrete form, as just noted, in the ease with which the hypothesis becomes a controlling idea. To avoid this grave danger, the method of multiple working hypotheses is urged. It differs from the simple working hypothesis in that it distributes the effort and divides the affections. It is thus in some measure protected against the radical defect of the two other methods. In developing the multiple hypotheses, the effort is to bring up into view every rational explanation of the phenomenon in hand and to develop every tenable hypothesis relative to its nature, cause, or origin, and to give to all of these as impartially as possible a working form and a due place in the investigation. The investigator thus becomes the parent of a family of hypotheses; and by his parental relations to all is morally forbidden to fasten his affections unduly upon any one. In the very nature of the case, the chief danger that springs from affection is counteracted. Where some of the hypotheses have been already proposed and used, while others are the investigators' own creation, a natural difficulty arises; but the right use of the method requires the impartial adoption of all alike into the working family. The investigator thus at the outset puts himself in cordial sympathy and in parental relations (of adoption, if not of authorship) with every hypothesis that is at all applicable to the case under investigation. Having thus neutralized, so far as may be, the partialities of his emotional nature, he proceeds with a certain natural and enforced erectness of mental attitude to the inquiry, knowing well that some of his intellectual children (by birth or adoption) must needs perish before maturity, but yet with the hope that several of them may survive the ordeal of crucial research, since it often proves in the end that several agencies were conjoined in the production of the phenomena. Honors must often be divided between hypotheses. One of the superiorities of the multiple hypotheses as a working mode lies just here. In following a single hypothesis, the mind is biased

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[49] Jour. of Geol., Vol. V (1897), pp. 843-45.

by the presumptions of its method toward a single explanatory conception. But an adequate explanation often involves the co-ordination of several causes. This is especially true when the research deals with a class of complicated phenomena naturally associated but not necessarily of the same origin and nature, as, for example, the Basement complex or the Pleistocene drift. Several agencies may participate not only but their proportions and importance may vary from instance to instance in the same field [sic]. The true explanation is therefore necessarily complex, and the elements of the complex are constantly varying. Such distributive explanations of phenomena are especially contemplated and encouraged by the method of multiple hypotheses and constitute one of its chief merits. For many reasons we are prone to refer phenomena to a single cause. It naturally follows that when we find an effective agency present, we are predisposed to be satisfied therewith. We are thus easily led to stop short of full results, sometimes short of the chief factors. The factor we find may not even be the dominant one, much less the full complement of agencies engaged in the accomplishment of the total phenomena under inquiry. The mooted question of the origin of the Great Lake basins may serve as an illustration. Several hypotheses have been urged by as many different students of the problem as the cause of these great excavations. All of these have been pressed with great force and with an admirable array of facts. Up to a certain point we are compelled to go with each advocate. It is practically demonstrable that these basins were river valleys antecedent to the glacial incursion. It is equally demonstrable that there was a blocking-up of outlets. We must conclude then that the present basins owe their origin in part to the pre-existence of river valleys and to the blocking-up of their outlets by drift. That there is a temptation to rest here, the history of the question shows. But on the other hand, it is demonstrable that these basins were occupied by great lobes of ice and were important channels of glacial movement. The leeward drift shows much material derived from their bottoms. We cannot therefore refuse assent to the doctrine that the basins owe something to glacial excavation. Still again it has been urged that the earth's crust beneath these basins was flexed downward by the weight of the ice load and contracted by its low temperature and that the basins owe something to crustal deformation. This third cause tallies with certain features not readily explained by the others. And still it is doubtful whether all these combined constitute an adequate explanation of the phenomena. Certain it is, at least, that the measure of participation of each must be determined before a satisfactory elucidation can be reached. The full solution therefore involves not only the recognition of multiple participation but an estimate of the measure and mode of each participation. For this the simultaneous use of a full staff of working hypotheses is demanded. The method of the single working hypothesis or the predominant working hypothesis is incompetent."

These were the basic principles of his scientific life and characterized his serious thought in other fields as well as science. They were already strongly in evidence in his youthful work on the lead and zinc problem in Wisconsin and continued to dominate his most mature cosmogonic researches. "Probably at no time in his career as an investigator did Chamberlin more courageously apply the method of multiple hypotheses than when, as a veteran of eighty odd years, he undertook to review and revise his work on the origin of the earth."[50] "No one else knows so well as I do that his every instinct and the habits of a lifetime kept him from ever making the planetesimal hypothesis a 'ruling theory.' To his last days he never ceased to regard it as a hypothesis to be put to the test in every possible way, rather than as an expression of final truth. . . . How seldom have these precepts been followed in science or philosophy! How different in many cases the results would have been had they been followed! What need there is for them also in social and political sciences, in theology, and in all the varied interests of the human mind!"[51]

The serenity of mind requisite for the long-sustained and successful journeys into the unknown was made possible by a happy home life which fortified him for his manifold tasks. What greater blessing can a man have than a sympathetic and understanding wife? What is more helpful than to find home ever a haven of rest from the cares and disappointments of the day's struggles? The difficulties melt away in the peaceful quiet of the happy home and the morrow starts fresh and full of promise. In this all-important part of his life, Thomas Chamberlin was particularly blessed. Mrs. Chamberlin was indeed his ideal counterpart. She was home-loving, quiet and somewhat retiring by nature, but practical and capable and strong in the optimistic faith brought over from the previous pioneer generation. Though naturally proud of the achievements of her husband, successes or failures were not allowed to alter the cheerful, even tone of the family fireside. For well over half a century their life together was singularly harmonious and happy. When, at length in the summer of 1923, she was the first to answer the final call, it seemed as if he too, so dependent on her in many ways, might not long survive the parting. But her spirit continued with him in effect and he carried on for five years more.

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[50] Bailey Willis, Dynamics is the Soul of the Problem. Jour. of Geol., Vol. XXXVII (1929), p. 362.

[51] F. R. Moulton, Thomas Chrowder Chamberlin as a Philosopher. Jour. of Geol., Vol. XXXVII (1929), pp. 372-73.

It was always a source of satisfaction to the father that his son, the writer of this memorial, chose to follow in the same line of work. They had many things in common and their companionship was most congenial. From early childhood the father talked to the son as to a grown person and so spontaneously there developed a complete understanding between them. In later years of more philosophical trend, he outlined elaborately his inmost thoughts in many of the different realms into which the human mind penetrates. Screen after screen seemed to be lifted before long vistas into the hidden beyond. The inspiration was tremendous, and the poetic beauty of the vistas beyond description. But only the magic lamp of a master can illumine such portals; when the light is removed, one is left groping, though groping with a little more confidence for the visions which have been revealed.

At the close of the academic year in 1918, when approaching his seventy-fifth birthday, Chamberlin retired from the University. He continued, however, as senior editor of the *Journal of Geology,* but gradually lessened the load of outside demands on his strength. His time he now considered his own, to be utilized to the best advantage. Researches, as ambitious as any of former years, continued to fill his mind and to keep him conscious of how much he still had to do in the next few years.

He was working more slowly now. Cataracts had been dimming his vision gradually for a decade and all reading now had to be done through a large hand glass, but he toiled on without complaint. An operation to remove the opaque crystalline lenses had seemed the ultimate solution of the difficulty, but conditions did not reach the point where an operation was advisable and it was never attempted. Fortunately the eyes served for ten years more. His general health, which already had occasioned some alarm, now improved perceptibly. Needing more time for his work so badly, in his characteristic way he turned his power of analysis and experimentation upon his stomach problem and eventually developed a regimen of treatment and control which accomplished the desired results and carried him along.

Ten years for the continuation and rounding up of his researches were eventually allowed him, and approximately one-fifth of all his published papers appeared in this decade. A perusal of the bibliography will show their diverse scope and the breadth of interest which he still retained. All were mature productions, as might be expected, but some were as highly original as the inventions of youth. Even the final year brought little loss of mental vigor. Significant and fitting it was that his last publication, "The Two Solar Families," which came from the press on his eighty-fifth birthday, should be one of the finest of all his productions. A few days more and his busy life was over. Like the evening star in the mountains which shines, full of glory, undiminished till the end, his work continued to this brilliant close. A companion volume was in prospect, but the light was cut off too soon.

This continued devotion to duty was an expression of his belief in the value of his researches. Partly as the result of a successful life and partly because of his habitual thoroughness in following the method of multiple working hypotheses, he came to have great confidence in his judgment. If, at times, he seemed impatient of some other views which were different from his own, it was only because he felt that their sponsors had not considered the ramifications of the problems so carefully or so thoroughly as he had, and hence were less qualified to express judgment. Filled with enthusiasm by his message he wished to deliver it in full.

He was deeply religious in the truest sense, and the call of duty came likewise from his belief in the honesty of the Cosmos, as he expressed it, and from his prophetic outlook on life and its proper place in the Universe. The long geologic retrospect gave a basis for peering into the future. For hundreds of millions of years balanced processes have kept our globe a fit abode for life. A regulated system with orderly development has prevailed. Life has progressed to higher and higher levels. What has characterized the past is likely to characterize the future and the end seemed to him far distant. The heights to which the human race may attain, if it but utilizes its intelligence and knowledge to the best advantage, are likely to be far beyond our liveliest imagination. He sometimes remarked that if there were only a few thousand years ahead, much of the satisfaction which he took in his work would be lacking. But as the presumption is in favor of ages to come as long as those of the past, he believed that whatever good one truly accomplishes, if the results are to carry on as constructive factors in an advance for millions of years, may in the aggregate prove to be of inestimable value. This was his optimistic dream; he laid his few bricks and mortar with genuine satisfaction, and confidently looked to others to build higher and better in the long time to come. Now his own little bit is done; may the future substantiate his inspiring prophecy.

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NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA

BIOGRAPHICAL MEMOIRS
PART OF VOLUME IX

# BIOGRAPHICAL MEMOIR

OF

# WILLIAM BULLOCK CLARK

1860-1917

BY

JOHN M. CLARKE

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1918

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WILLIAM BULLOCK CLARK was born in Brattleboro, Vt., December 15, 1860. He died suddenly of apoplexy, at North Haven, Me., early in the morning of July 27, 1917. He passed away in the prime of his life and usefulness.

Doctor Clark was of old American lineage. His father was a merchant at Brattleboro—a man of worth and held in high regard in his community. The father's family was derived from Thomas Clarke (the final *e* was in the spelling of the name for several generations), of Plymouth, who, though not of the *Mayflower* company, was a notable and vigorous figure in the colony after 1623, the date of his arrival. From this progenitor have sprung fertile and sturdy legions of Americans. With the Bullocks the same strong strain entered the combination. On both sides were men who, in their various generations, served colony and king and republic in military and civil office from the battle of Lexington to the founding of this Nation. In these late days it is of more than passing note that through the early years of the generations this combination of Clark and Bullock was of pure strains which had never crossed with Cavalier or Quaker or such other haphazard invaders of King James's American plantations, nor in later years with newer alien stocks.

In the wanderings of the descendants of Thomas Clarke and his contemporaries, the families had spread from Plymouth along the coastlines to Stonington and New London and thence up the Connecticut River. This route was "Puritan Street"—the line of migration beaten out by one generation after another and which gave the way for the settlement of the western wilderness. Few ventured the shorter cut from Massachusetts Bay through the savage forests and lurking dangers of Wellesley, Framingham, and Worcester. So to the upper waters of the Connecticut and to Brattleboro came Dr. Clark's immediate progenitors, and there he was born—a son of a substantial and respected father and of a strong-hearted mother. Obedient to the recognized procedure of heredity, Dr. Clark is said to have derived much of his intellectual vigor and agility from his mother; but it would be beyond my power or wish to think of Dr. Clark or to present him to others as a composite of ancestral traits; rather as a unit of character and work.

In the home at Brattleboro there were influences indoors of the Christian fireside and outdoors of the attractiveness of the river and its bounding hills. There, too, was the busy industry of the town, with its commercial ambitions. One may perhaps find it possible to trace back into some of this youthful environment the threads which were to be woven into the manhood fabric; yet, after all, the boy lived a normal, healthy Yankee boy's life, and as schooling days in Brattleboro drew to a close was, like other Yankee boys, possessed with the desire to go to college. I have learned of no special proclivities toward geology which Clark had acquired from the granite hills and river clays of Brattleboro; but I have learned over and over again that in the making of a boy into a man there is some one individual's influence that is likely to dominate all others, leave a deep imprint, and often turn the feet into a determined path. So I think we may say of Dr. Clark, as I once had occasion to say of his predecessor at the Johns Hopkins, there was nothing startling, premonitory, or out of the ordinary in his school and college career; but that, always a good student, leaving behind a reputable record, he was not awakened to a real purpose in life until he was led into the circle of the sciences which are concentric to geology; and this was in Amherst College and the torch-bearer was then, as before and since, Professor Benjamin K. Emerson.

A singular physiology determined the direction of Clark's career in geology. Professor Emerson was then in a quartan fever of enthusiasm over the new petrology and was keenly disposed to induct his students into its fascinations; but as it happened Clark was, in a moderate degree, color-blind and the nicest discriminations of the crossed nicols were not for his eyes; so perforce his efforts were directed into the standard lines of geology—structure, stratigraphy, and paleontology. It was for the pursuit of these aspects of his science, colorless in a certain sense, but vastly colorful in their chief reactions, that on graduation in 1884 he left Amherst for Europe with the inspiring companionship of Professor Emerson and Professor William North Rice, both of whom were going off together for a year's holiday. This was such an opportunity for travel and uplifting fellowship as seldom falls to a young man's lot. In journeys through Scotland and down into Cornwall and Devonshire, up the Rhine and into Switzerland, their scenery and geology expounded by his extraordinary couriers, amid the exciting surroundings of new lands, the student was electrified by the allurements of his science. Everywhere he made notes and collected specimens, meanwhile conning his vade-mecum—Dana's *Manual*. Professor Emerson intimates that on this trip Clark was unfailingly thoughtful of the whimsies of the distinguished zealots who were acting as his spiritual guides.

Arriving at Munich, he was advised to settle down and study with Zittel, then the leading paleontologist active in the universities of Central Europe. There, and also for a short time at Berlin, he had the experience which so many American students of those days shared; an opportunity to acquire the precision of German procedure while, like others, he unwittingly succumbed to the ingratiating propaganda of Teutonic national ideals. As Munich was in the heart of a region where the Mesozoic and Tertiary rocks were richly developed, Clark's special interest was turned in their direction, and he always afterward pursued, by preference, investigations in this field.

Prof. George Huntington Williams, then at the head of the newly organized Department of Geology at the Johns Hopkins University, wholly enamored of the Zirkel-Rosenbusch petrology, a scholarly investigator of the best type after the German model, felt the need of assistance in the organic phase of geology, and through him Dr. Clark, who had made his degree at Munich, was invited to that institution which through the rest of his life was to be the stage and setting of his successful career.

Memorial tributes in other places have dwelt upon the growth of Dr. Clark's influence in the university, and there is today a widespread cloud of witnesses to his successful labors in the scientific army of this nation. So we may perhaps wisely summarize the university phase of his life in a few paragraphs.

It is the misfortune of a teacher's career that it cannot be defined in terms of the influences it imparts. The portrait must always fail in some intangible measure when it is drawn in words alone. A student's memories and the influence for good which he in his day transmits are the most subtle and doubtless the most enduring of all tributes to a successful teacher, and these we may leave to the generations of his disciples. Williams and Clark were a strong team at the Hopkins; Williams, the erudite and polished scholar, refined in research, hesitating a little to step down to the street from his cloister; Clark, with a big heart open to all men, eager to carry his message and his science to all the people, a splendid mixer and propagandist, with an unwearied enthusiasm for ever more work and a genius for organization. When, in the vicissitude of life, Clark took charge of the department, he brought into it a spirit of living emulation and freer interchange. The ascetic cells were none the less regarded, but their devotees were turned out for frequent airing, made to meet the man on the street and understand his claim upon them. Professor Clark strengthened his own hands immensely in the wise choice of his strong associates in academic work; Mathews, the sturdy, clear-headed geologist and executive; Reid, the fine-strained, acute geophysicist; Swartz, the versatile teacher; Berry, the animating expositor of these academic groves.

The students who gathered around him caught his ideals; there was to be no specializing among them till they had covered the entire broad field of the science, organic and inorganic, and were then in some more adequate measure inoculated with his vision. That this paleontologist graduated from his department geologists, paleontologists, paleobotanists, geophysicists, highway engineers, and meteorologists was a natural realization of his proper university business; but a more vivid expression of his earnest conviction that geology is an essential science is the fact that he had convinced the engineering faculty of the imperative need of the full undergraduate course in geology for candidates in civil engineering.

Professor Clark became head of his department in 1894, but before he had reached this position he had contracted an affiliation with the U. S. Geological Survey which gave him an official standing therewith, and this in variant form was continued to his death. It was a connection extending over almost thirty years, from 1888 to 1917, and it had a very important influence on his life work in opening to his study, and in large measure to his eventual official control, the problems of the Cretaceous and Tertiary formations of the Atlantic Coastal Plain. Correlation in stratigraphy and paleontology in this region was vastly obscure at the time Clark began his work. The lamented McGee, with an unerring genius, had pointed the way out of the chaos of accumulated discrete data; but it is safe, I think, to say that in this field the work of many hands, guided by or coöperating with Dr. Clark, has brought to the science not alone a resolution of the outstanding problems, but a detailed and applied knowledge of practical resources before unknown.

In 1892, while still holding a subordinate position in the university, he made his first trial of outside organization and brought into existence the Maryland State Weather Service, of which he was made Director and as such continued until his death. A deeply interested and experienced student of climatology has characterized Clark's weather reports as the best ever made in this country.

In 1896, now with all his influence of a full professor in the Hopkins, he effected the creation of the Maryland Geological Survey, receiving the official title of State Geologist and safeguarding the organization by the creation of a Board of *ex officio* commissioners, of whose sympathy and support he might under all conditions feel reasonably secure. To such sympathetic and understanding support the noteworthy product of this Survey in no small way is due. It is almost needless to say that this organization, of all his creations, lay nearest his heart and that its volumes are his most tangible monument. Perhaps it is true that only those who have been charged with State geological surveys can fully appreciate the quality of this achievement, that is to say, only such men as have been confronted by similar problems in the effective manning of such a survey; the execution of essential details, the presentation of them to the public in inviting form, the whole mechanical paraphernalia thereto attached, and, of course, of prime moment, the securing of appropriations in such form and amount as to make the work free of embarrassing interruption. I believe it fair to say that the impulse toward the organization of this Survey may have begun to take form from the time Professor Williams and Dr. Clark were called on to prepare a treatise on the Geology and Mineral Resources of Maryland for the use of the World's Fair Commission in 1893. This document was of such broad and general scope as to summarize not only the outstanding knowledge, but the outstanding lack of knowledge as well.

The first official volume of reports on the Geological Survey was not issued till 1897, and naturally it was given over to a presentation of the general field, the history of such scientific investigations in the State, and the scope and importance of the problems involved in the undertaking. The first report of a newly created official departure is awaited with a critical keenness by the tax-payers, and the prescient Clark knew that the fate of his organization largely hung on the reception of his maiden volume; so he gave them an untechnical, readable book whose mechanical execution was worked out in the very best taste, with miniature geological maps rendered with a beauty of execution we had not seen before, carefully selected paper and letter-press, a dignified format and binding, the whole making a most attractive and desirable book. So his people estimated it, for its reception was laudatory and encouraging; and so his colleagues have estimated it in terms of the worldly wisdom which took this way to open the door to the technical volumes which followed. There are now ten volumes in this series, the last of which Dr. Clark's eye never saw. They are familiar to all of us geologists and they make a sumptuous array of varied and inviting books—the compendium, now that they have run through the gamut of the formations, of the economic, stratigraphic, and paleontologic facts of the State of Maryland.

Into this fruitful survey of his adopted State he brought a battalion of collaborators and independent workers. It may be said that he subsidized the best talent he could find for these geological problems, and it would be a long and strong list if I should here call the roll of these shareholders. If one should say, herein lay his good generalship, that he could impress so many to his service, and that a too ponderable share of the load was laid upon the shoulders of his effective aides, let this critic look through the contents of these volumes and learn the very large part which Dr. Clark's own hand has played in the creation of their technical contents.

No sooner was the geological organization on its feet and fortified by the plaudits with which its first volume was greeted than Clark took advantage of the good-roads propaganda, which was then spreading through the Eastern States, to organize a Highway Division of the Geological Survey. The construction of a system of public highways for a Commonwealth calls for executive ability of the first order. It must commandeer high-grade engineering, prudent financiering, and astute appreciation of community and commercial requirements and avoid the emaciated political sniper. It also takes money in great sums. From 1898 to 1910, after an expenditure of $2,000,000, when the importance of the work made necessary the organization of a separate board—the Maryland State Roads Commission—these activities were carried on by the Geological Survey, and their successful appeal to the people greatly strengthened the organization, perhaps in such degree that it was freer to stroll away among the aisles of pure science, from which during this period emanated so many of the volumes on paleontology.

"The fine roads that now run through Maryland counties are in no small measure the result of his sound advice and far-seeing counsel," said the *Baltimore American*, in commenting on the death of this "most useful citizen."

Professor Clark was made a member of the new commission, and so continued until 1914.

Ten years ago the problems of forest protection and development were subtending a large angle in the public vision, and at that time Dr. Clark was made executive officer of the Maryland State Board of Forestry, and with the parturition of the term *conservation* at the celebrated "Governors' Meeting," called by President Roosevelt at the White House, and, as one might say, the "pinchoting" of "conservation commissions" over the land, Clark was appointed by the Governor a member of Maryland's Commission.

The foregoing may be taken as the summary, or rather as an inventory, of Professor Clark's scientific activities; in them all he showed the initiative of the pioneer, I think an inherited trait. His ancestors "pioneered" from England to Plymouth; from Plymouth to the mouth of the Connecticut; from there to Brattleboro; then he "pioneered" from Brattleboro to Baltimore, where the atavistic geographical sense of organization seems to have been converted into the initiative for organization. But the scientific side of his life is only a part of his story. He entered without reserve into a man's share of civic life and duty and his competency to serve was recognized both by State and city. By act of legislature he was made Commissioner for the State of Maryland in the resurvey of the Mason and Dixon line. The Mayor of Baltimore, Mr. McLane, after the great fire of 1904, made him a member of a committee to rehabilitate the burnt district, and in that work he served as vice-chairman of the Subcommittee on Streets, Parks, and Docks; and I recall the proper pride with which he pointed out to me on one occasion the improvements which resulted from these labors. By Mayor Timanus he was appointed a member of a Commission on City Improvements and he was one of the first advocates of the present system of sewers. Again he was made a member of the Mayor's Committee to widen the down-town streets and create a civic center for the city. From 1901 to his death he was president of the Henry Watson Children's Aid Society of Baltimore, and this interest led him into a deep concern for problems relating to the dependent child, in which his judgment was so highly regarded that he was a delegate to the White House conference on this theme in 1909. He was also a member of the State Tuberculosis Association and vice-president and chairman of the Executive Committee of the Federated Charities of Baltimore.

Thus he gained esteem and confidence among his neighbors, the citizens of his vicinity—not an easy thing for a man of science, who is so freely condemned as "unpractical" by the so-called man of affairs. And these many lines of civic industry he carried without friction or loss of tone and never to an interference with his scientific labors and ambitions.

To enumerate the marks of appreciation of his scientific work would make a long list. I am not sure that Dr. Clark ever kept a complete one, but these were the progressive orders of his advancement: he belonged to American, English, and German geological societies; he was a member of the National Academy of Sciences and chairman of its geological section; of the American Philosophical Society; president of the Association of American Geologists; the treasurer of the Geological Society of America.

A few years ago, when Dr. William M. Davis was about to retire from the Sturgis-Hooper Professorship of Geology at Harvard, Clark was asked by Professor Davis and President Lowell to take the position. He was attracted by the offer. The venerable prestige of Cambridge, the large opportunity of expansion, the cozy repute of such an attachment, together with a certain pious genealogical appeal, made a strong argument to him; but the child of his creation was dearer to him than any child of adoption could be. He came to Albany to talk the matter out with me, and I was told afterward, when he had decided not to go, that the only condition of his remaining which he asked of his trustees was that the salaries of his colleagues should be increased.

Doctor Clark was an LL. D. of Amherst College, and probably might have been its president had he been so disposed. His administrative relations to the Johns Hopkins University during the interregnum after the retirement of President Remsen were so influential that many eyes were turned on him as a probable successor to the vacant chair. R. Brent Keyser, President of the Trustees of the Hopkins, speaking at Dr. Clark's public memorial,* has said of this: He "was among the first to be mentioned to fill the vacant position. I therefore asked him frankly for his attitude in regard to presidents, and he replied that while he appreciated fully the opportunities, honor, and dignity of the position, he was convinced that the university wanted a man outside of the faculty;

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* Held at the university, November 5, 1917.

and he at once threw himself whole-heartedly into the search for the outside man. In all matters in which the university was involved," added President Keyser, "he occupied the dual position of the man keen after its material prosperity, but even keener to guard its spiritual ideals."

Dr. Clark traveled widely, both in the far-flung excursions of the international geological congresses and with his family on many occasions. For many years he had made a summer home at North Haven, Me., and in his outings during vacation days at "Stonecrop" he threw his official cares aside and was always the wholesome, hospitable man-boy, bubbling with energy, gardening, raising chickens, building boats and sailing them, reveling in unchecked return to the instincts of Brattleboro days.

Doctor Clark married Ellen Clarke Strong, daughter of the late Edward A. Strong, of Boston, and descendant of William Clarke, of Dorchester (1637) and Northampton; and their four children, Edward, Helen (Mrs. H. Findlay French), Atherton, and Marion, share an unsullied strain of Puritan descent.

Thus, briefly, we have summoned together for this sketch the outstanding facts of Dr. Clark's life. Much of his record must remain untranscribed except upon the hearts of those who received his impulses and his confidences.

For some time before his death a heightening blood pressure had warned Dr. Clark of dangers ahead, but his undiminished vitality seems to have made him indifferent to the signal. In the spring of 1917 he was appointed to the Geology Committee of the National Research Council on nomination from the National Academy of Sciences and was asked to take over the organization of a plan which would locate, chart, and describe the entire supply of materials available for rapid highway and fortification construction from Maine to Texas and for 100 miles back of the seaboard. He entered on this undertaking with his customary energy, even though at the time serving as a member of the Maryland State Defense Council, and he effected a large and efficiently coöperating organization of about fifty geologists and highway engineers. This was his chief service for the war and he fell in the midst of it. Other hands have with prudence and efficacy brought the work to its completion, and it will stand as his last monument and a permanent memorial.

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# BIOGRAPHICAL MEMOIR

OF

# FRANK WIGGLESWORTH CLARKE

1847-1931

BY

L. M. DENNIS

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1932

# FRANK WIGGLESWORTH CLARKE

## March 19, 1847, to May 23, 1931

BY L. M. DENNIS

Some two centuries ago, Robert Clarke, a member of the Scotch colony near Londonderry, Ireland, came to this country and settled in Londonderry, New Hampshire, about 1725. A grandson of Robert, Samuel Clarke, was a Unitarian Minister located first at Princeton, and later at Uxbridge, Massachusetts. A son of Samuel Clarke, Henry W. Clarke, married Abby Fisher, and their son, Frank Wigglesworth Clarke, the subject of this memoir, was born in Boston on March 19, 1847. Professor Clarke's grandmother on his father's side was Sarah Wigglesworth, granddaughter of Col. Edward Wigglesworth of Washington's army, and great-great-granddaughter of Michael Wigglesworth, the author of the "Day of Doom," a Puritanical poem that was popular in the 18th century. Michael was descended on the mother's side from Anthony Fisher, who settled in Dedham, Massachusetts, about the middle of the 17th century.

Professor Clarke's father, Henry, was first a hardware merchant in Boston, and later a dealer in iron-working machinery. His mother died when he was about ten days old, and Clarke's earliest childhood was spent with his grandfather at Uxbridge. In 1851 his father married again and lived for about eight years in Woburn, ten miles from Boston. He later removed to Worcester, but returned to Boston in 1866, making it his home in the suburb of Watertown, where he resided until his death in 1907.

From 1857 to 1869 Frank's time was mainly divided between his father's home and that of his grandmother Fisher in Boston. As a result of this frequent moving about, his early education was disconnected. He began his regular schooling in Woburn, was then for sometime at Uxbridge, and following a year or two in a boarding school at Stoughton, Massachusetts, he attended several different schools in Boston. After a year in the Boston Latin School he went to the English High School, and in March 1865 he entered the Lawrence Scientific School of Harvard University, where he took up the study of Chemistry under Wolcott Gibbs, receiving the degree of B. S. in 1867.

But as Professor Clarke was wont to say, "formal schooling is only a small part of education." He learned to read before he went to school, and he thought that he picked up his letters from blocks that had been given to him for playthings. Even before entering his first school at Woburn he was reading Robinson Crusoe and the Arabian Nights. He recalled that at Woburn he was particularly interested in Colburn's mental arithmetic, from which he derived valuable training. Problems were given out which had to be clearly stated by the student and then orally solved in a logical manner. Clear reasoning was required, and he felt that that training stood him in good stead throughout his life. He was early interested in geography, but he greatly disliked the study of grammar, although he was a very accurate speller, an accomplishment that he thinks was developed by his omnivorous reading, in which he was later given opportunity to indulge through access to the public library in Boston.

Like all healthy boys he greatly enjoyed outdoor sports, such as swimming, boating, and fishing, and he early developed the collecting instinct, being interested in coins, pressed flowers, and especially in minerals. His interest in minerals seems to have dated from the time when a visitor at his grandfather's gave him a pebble of chlorastrolite. This was the beginning of a small mineral collection and his interest in mineralogy. As a youth he visited the well-known mineral deposits at Lancaster and Boulton, Massachusetts, and on this and other excursions he learned much concerning the natural occurrences of minerals.

His interest in chemistry seems to have sprung from the perusal of a copy of "The Boys' Own Book" which was given to him when he was about eleven years old. The section on chemical experiments fascinated him, and a few years later, in association with some of his playmates, he got together a small supply of cheap apparatus and chemicals with which they had, as he expressed it, some successes and many failures. But in this boyish study he acquired some knowledge of manipulation of apparatus which was of value to him when he later entered the Lawrence Scientific School.

Allied to his interest in making collections of specimens was his bent for arranging his information in tabulated form. When he was about eight years old he was given a copy of Mayne Reid's "Boy Hunters" in which many birds and plants were described. Fascinated by their names, he carefully tabulated their characteristics without any suggestions from older people. This instinctive urge to tabulate data led in later days to the production of some of his most important and valuable scientific work.

After graduation from the Lawrence Scientific School in 1867, he remained there for an additional year to carry on research, and in March 1868 he published his first scientific paper, "A New Process in Mineral Analysis." During that year he also lectured on chemistry in the newly established Boston Dental College. In January 1869 Clarke went to Cornell University as assistant to Professor J. N. Crafts and remained there until the close of the academic year. While at Cornell he found much pleasure in exploring the many ravines near Ithaca and wrote a guide book to that region which was published by a local concern. He also there worked out an excellent method for separating tin from antimony.

The next four years were spent in a rather itinerant manner—lectures in the Boston Dental College, in a private school, and in some popular courses, reporting Tyndall's Lowell Institute Lectures for the *Boston Advertiser,* journalistic work, articles to several magazines, and occasional verses—anything to add to his small income.

He did not, however, neglect his scientific work. In 1873 he wrote for the *Popular Science Monthly* an article entitled "Evolution and the Spectroscope," pointing out that the evolution of planets from nebulae had been accompanied by the evolution of the chemical elements from their simplest forms. A "Table of Specific Gravities, Boiling Points, and Melting Points of Solids and Liquids" was accepted for publication by Joseph Henry, Secretary of the Smithsonian Institution, who made it the first of a series of articles to which he gave the name "Constants of Nature." This was later followed by other similar tables, several of them by Clarke, and one by G. F. Becker. In 1873 he received appointment, largely through the influence of Professor Henry, to the Professorship of Chemistry, Physics, etc., at Howard University in Washington. In the following year he married Mary P. Olmsted, of Cambridge, Massachusetts, and in September he went to the University of Cincinnati as Professor of Chemistry and Physics, where he remained for nine years.

At Cincinnati his duties at first were largely routine, but he soon equipped a small but satisfactory laboratory and published several investigations. It was while there that he wrote his noteworthy article on the "Recalculation of the Atomic Weights" which appeared as one of the series of the "Constants of Nature" of the Smithsonian Institution.

In 1883 Clarke was appointed Chief Chemist to the United States Geological Survey at Washington, and Honorary Curator of Minerals of the United States National Museum, and these positions he held until his retirement on December 31, 1924.

The work in the Survey was of the most varied character, comprising many routine analyses to assist geologists, analyses of waters of the Yellowstone Park, and of igneous rocks and rare minerals. Personally he carried out investigations in the field of Geochemistry, and he always regarded his researches in this field as his most important scientific contributions. The results were summarized in his volume "The Data of Geochemistry," which ran through five editions issued as Survey Bulletins.

Apart from his regular duties as Chemist for the Survey, Clarke was called upon for service in connection with the government exhibitions at several expositions, and at the close of the Paris Exposition in 1900 the French Government awarded him the decoration of chevalier of the *Legion d'Honneur*.

In 1903 the centenary of Dalton's Atomic Theory was celebrated at Manchester, England, and on that occasion Clarke delivered the Wilde lecture and received the Wilde medal. In 1909 he delivered before the Chemical Society of London a lecture in memory of Wolcott Gibbs, his former teacher. Many universities conferred upon him honorary degrees and he was associated, either as member or as honorary member, with many scientific societies in this country and in Europe.

Not long after the appearance of the first edition of Dr. Clarke's "Recalculation of the Atomic Weights," three similar but less complete revisions were published in Europe, by Meyer and Seubert and by Ostwald in Germany, and by Sebelin in Norway. The American Chemical Society, recognizing the fundamental importance, both to scientific research and to the chemical industries, of correct data concerning the atomic weights of the elements, appointed Dr. Clarke a committee of one to prepare an annual report on the subject, and annually to compile a table of atomic weights for official use in this country. His first report was presented to the Society at the Baltimore meeting in December, 1893. In 1897 the need for an official table of atomic weights for German analysts was brought before the German Chemical Society, and a committee of three, Landolt, Ostwald and Seubert, was appointed to consider and report upon the question, which they did on October 31, 1898. They used Oxygen = 16 as the basis for the atomic weights, a value that Clarke had provisionally adopted for his table of 1893. In their report Landolt called attention to the desirability of international agreement concerning these values, and the German Committee issued on March 30, 1899 an invitation to the Chemical Societies and similar organizations of the United States and the leading countries of Europe to nominate members of an International Committee. The Committee thus created consisted of more than fifty members, the representatives of the American Chemical Society being J. W. Mallett, E. W. Morley, T. W. Richards, E. F. Smith, and F. W. Clarke, Chairman.

It was soon found that this large committee was too unwieldy for efficiency, for its work had to be carried on by correspondence which caused long delay in the preparation of its report. For this reason the members of the Committee from the German Chemical Society addressed to the members of the large Committee the question as to whether the periodic preparation of a table of Atomic Weights should be placed in the hands of a much smaller committee. The answers to this inquiry being strongly in the affirmative, the members were asked to send in nominations for a committee of three. Those receiving the highest number of votes were F. W. Clarke, America, T. E.

Thorpe, England, and K. Seubert, Germany. Clarke was asked to act as chairman of the committee, a position that he held until 1918 when the World War caused the temporary discontinuance of the International Committee.

One of Dr. Clarke's greatest services to chemistry in this country was in connection with the creation of the American Chemical Society. Up to 1873, chemistry had been given but scant attention in the meetings of the American Association for the Advancement of Science. In that year, at the meeting at Portland, Maine, four young men, C. E. Munroe, W. McMurtrie, H. W. Wiley and F. W. Clarke, presented a request that chemistry be more adequately recognized by the formation of a subsection of chemistry, now Section C. The request was granted, and the section held a successful meeting at Hartford in the following year. In 1876 the chemists of New York City organized a local society to which they gave the name American Chemical Society, and some eight years later another local society of chemists was formed in Washington. The American Association met at Cleveland in 1888, the chairman of the chemical section at that time being Dr. C. E. Munroe. Dr. Clarke wrote to him and suggested the formation of a really national Chemical Society. Dr. Munroe favored the idea, and after some three years of discussion of the project, in which Dr. Clarke took an active part, a compromise proposal of the New York Society was adopted. This was, that if the chemists of the country would accept the name and charter of the New York organization, that society would form a local section of a truly national society, the Washington society to take the same action. This national society has now become the largest chemical society in the world, with eighty sections and nearly 19,000 members. Dr. Clarke was elected to the presidency of the society in 1901.

The numerous articles from his pen upon a wide variety of subjects that appeared in divers journals and magazines furnish abundant evidence of the breadth of his interest and the scope of his knowledge and of his gift of felicitous and convincing expression.

He was one of the most kindly and lovable of men, simple in his tastes and modest and unassuming. His sense of humor and ready wit gave to his conversation a delightfully piquant flavor and it was a most entertaining experience, which the writer often had the privilege to enjoy, to listen to his reminiscences, sometimes keenly critical, sometimes highly amusing, but always sympathetically appreciative, of the noted men whom he had known and of their scientific work. His was a long life, a happy and useful life, a life of helpfulness to others and of high achievement.

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# FRANK WIGGLESWORTH CLARKE

### COMPILED BY LUCIA K. WILLIAMS

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NATIONAL ACADEMY OF SCIENCES
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BIOGRAPHICAL MEMOIRS
VOLUME XII—EIGHTH MEMOIR

# BIOGRAPHICAL MEMOIR

OF

# JOHN MASON CLARKE

BY

CHARLES SCHUCHERT

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1926

PUBLISHED BY THE NATIONAL ACADEMY OF SCIENCES
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1928

John M. Clarke

"In the classroom of the venerable brown Albany Institute, Joseph Henry, a teacher of mathematics and physics, sent a galvanic current through a mile of copper wire and thereby created a circuit which, when broken, struck a bell. That little bell, a sacred relic, has sent its note around the world. That invention and discovery were the parent of the modern telegraph and telephone, the motor, the automobile, and the radio." The bell used by Henry in this experiment was secured by Clarke for the New York State Museum, and the portrait shows him with it.

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# JOHN MASON CLARKE

### BY CHARLES SCHUCHERT

In the death of John Mason Clarke, America loses its most brilliant, eloquent, and productive paleontologist, and the world its greatest authority on Devonian life and time. Author of more than 10,000 printed pages, distributed among about 450 books and papers, of which 300 deal with Geology, his efforts had to do mostly with pure science, and he often lamented, in the coming generation of doers, the lack of an adequate appreciation of wondrous nature as recorded on the tablets of the earth's crust. He was peculiarly the child of his environment; born on Devonian rocks replete with fossils, in a home of high ideals and learning, situated in a state that has long appreciated science, he rose into the grandeur of geologic knowledge that was his.

Clarke is survived by his wife, formerly Mrs. Fannie V. Bosler, of Philadelphia; by Noah T. Clarke, a son by his first wife, who was Mrs. Emma Sill (née Juel), of Albany; by two stepdaughters, Miss Marie Bosler and Mrs. Edith (Sill) Humphrey, and a stepson, Mr. Frank N. Sill. Out of a family of six brothers and sisters, four remain to mourn his going: Miss Clara Mason Clarke, who, with Mr. S. Merrill Clarke, for many years city editor of the New York *Sun,* is living in the old homestead at Canandaigua; Rev. Lorenzo Mason Clarke, pastor of the First Presbyterian Church of Brooklyn; and Mr. William B. Clarke, managing editor of the Baltimore *American.*

The cause of Clarke's death was a malignant growth in the sigmoid, which did not cause distress until the last few months of his life, and was not discovered to be such until three weeks before. He died under the fourth operation on May 29, 1925. On the afternoon of June first, a throng of his friends and fellow workers assembled in St. Peter's Presbyterian Church to listen to its beautiful service and to pay their last respects. He is buried in the Albany Rural Cemetery, where also lie James Hall, Ebenezer Emmons, R. P. Whitfield, and Philip Ast, all members of the New York State Geological Survey.

The present writer's acquaintance with Clarke dates back to the autumn of 1889, when he also joined Hall's staff at Albany, but as his private assistant. Then ensued delightful Thursday evenings with Clarke and his family, when we discussed our favorite fossil brachiopods and exchanged remarks about the doings of our strenuous chief. What glorious evenings of inspiration these were! When the writer went to Washington, he still met Clarke two or three times each year and our letters were frequent, and this same close relationship was continued to the end. We saw each other for the last time at the 1924 meeting of the Geological Society of America at Ithaca, and Clarke's last letter, of May 14, 1925, was in his characteristic style, but with an undertone of possible seriousness ahead. The last few days before going to the hospital were, in fact, spent in adjusting official matters between himself and his staff, and in giving helpful suggestions to the Regents of the New York State Museum regarding its future welfare.

No finer thing can be said of John M. Clarke than has already been said by another close friend and associate, Doctor John H. Finley, former president of the University of the State of New York and now editor of the New York *Times,* from whose columns the following quotation is taken:

> He endeared himself not only to those of his own field of science, which has to do largely with the past, but also to scientists in every field and to the people of the State generally, because of his intelligent, practical and helpful interest in everything in the realm of nature under, about and above man's daily life. He was the best friend of the birds, the trees, and the wild flowers. He was concerned even for the migratory birds that flew across the State, and he followed them to their homes in the Gaspé or elsewhere to protect them there. And though a scientist of the highest standing, he still insisted that Pan is not dead. "I have seen him oft," he said, "among the forests of the mountains," and heard him "rustling through the iris swamps" or caught a glimpse of him "in the shadows of the salmon pool or coming down the lavender banks of evening." He had not only the scientific eyes to see beneath the surface of the earth, but the ears to hear the "reedy pipes" that "sing everything that can be sung" and "tell everything that can be told."

During the Sixty-first Convocation of the University of the State of New York, the evening of October 15, 1925, was devoted to memorial exercises for Doctor Clarke, the speakers being the president of the University, Doctor Frank Pierrepont Graves, the Honorable William G. Rice, State Civil Service Commissioner, and Doctor Charles D. Walcott, secretary of the Smithsonian Institution. On this occasion, President Graves said:

> In the death of John Mason Clarke the scientific world has lost its greatest paleontologist; the United States its most brilliant literary scientist; the State of New York its foremost champion of historic monuments, scenic beauty, and natural resources; the department of education its most distinguished scholar, its foremost intellect, and its chief ornament; and each of its members his most admired and inspiring friend. It is possible that his equal may some time in the future enter this building to serve the state and the cause of scholarship and science, but this good fortune is scarcely to be expected.

Secretary Walcott also said, in part:

> New York State owes to Dr. Clarke an eternal debt of gratitude for preserving the records of its scientific activities of ninety years or more, and for developing and carrying on, as a part of the educational system of the State, a museum unexcelled among State museums. James Hall, the founder of the museum and the great scientific leader of New York State for fifty years, died with the impression that there was no one who would take sufficient interest to carry it forward as an educational factor in the life of the oncoming generations of the people of the State. He did not fully realize that the young man who had been associated with him for years had all the qualities essential to successfully sustain the work of the world-renowned State Geological Survey, and the upbuilding of a model State Museum. Dr. Clarke, by birth, training, ability, and spirit, was the ideal successor of James Hall, and it is to the honor and credit of the Regents of the University that they recognized his ability and fitness for the task and assigned it to him. Dr. Clarke effectively carried on a most important and valuable work, yet so quietly and modestly was it done that even those closely associated with him did not fully realize the contribution that he was making to science and to the reputation of the people of the State. His passing is a distinct loss to scientific interests in America, and to intelligent humanity throughout the world. The influence of such a personality extends through the medium of kindred minds to the men and women and to the boys and girls who are to be the future leaders and guardians of the material and spiritual welfare of the people of every nation.

## PERSONALITY

Clarke stood about five feet nine inches, was sparely built, and probably at no time weighed more than 150 pounds. Dark of complexion and blue of eye, he had a well balanced head and face, with a thin head of dark hair. In earlier life he wore a small mustache, but later on his face was clean shaven. Probably his most striking facial feature was his brilliant, alert, and flashing blue eyes, which portrayed much of the momentary feelings of the inner man; they were set in a face that even though rarely sad or stern, was not a smiling one. Ambitious, jealous of the New York Devonian, perhaps unduly suspicious at times, strong in likes and dislikes and quick of temper, he was easily aroused, and his face, and especially his eyes, changed with his mood. However, he usually had these phases of his make-up under good control. He was a great tease, and particularly brilliant in the company of ladies, delighting in the give and take of repartee, in which he was rarely outdone. He was richly endowed with imagination, which had its full play in his last book, "L'île Percée" (1923). Of sarcasm he had much, and woe unto the man who angered him into action! Always well groomed, eloquent in speech, pleasing in manner, and deliberate in action, he moved easily in society with the unconscious ease of one to the manner born.

Mentally, Clarke was brilliant, alert, orderly, and well trained. Always a lover of the worth-while in life, the beautiful in nature and art, and ever a hard worker, he quickly became a prodigious producer of excellent paleontologic and stratigraphic results. These qualities made of him also a collector of antique ceramics and furniture, and historian of the fisher-folk of Quebec, and they were reflected even more strongly in the unusual character of the museum under his direction, which is probably his best monument.

Clarke's ideals in science were of the highest, and his leanings were decidedly toward pure science rather than the applied aspects. At times he was very outspoken in this matter, lamenting that so few geologists nowadays go into science for the love of the work, and that most men take up the subject as a means toward a better living. This will of course always be so in most instances, and yet there is no denying that the tendency in the United States has long been alarming, and especially since 1914. Ever since the Great War our universities have found a marked dearth of good men to take up teaching, and the surveys look in vain for leading geologists and paleontologists. Accordingly, to make himself felt in this matter, Clarke at times overstated the situation, giving rise to ill feelings. On the other hand, he fully understood that the mining world can pay higher salaries to good men than can the universities and surveys, and yet it can not be said of him that as director of the Geological Survey of New York he neglected to develop the natural resources of the State. Certainly he did for the mining and engineering worlds ever so much more than did his predecessor.

Even though the New York State Survey and the Museum have long been under the guidance of the Regents of the University of the State of New York, the appropriations for their maintenance have to come through the state legislature. Therefore both Hall and Clarke have seen much of the regulation statesmen and their humorous, if not always wise, ways of doing things for science. Hall rarely was the gentle mixer with people, but his great prestige in science generally assured him success with the legislature. Clarke, on the other hand, had the gift of making good addresses and of meeting easily men of importance, and this, together with his caution in keeping abreast of coming events among the powers that are and are to be, made him a tower of strength behind the Regents. He was therefore much more successful in making things possible in the Science Division of the University than any of his predecessors.

## ANCESTRY

During the years previous to 1892, Clarke was searching out his family history, and in this year he completed the task and transcribed the information by hand on twenty-five cards 6 x 3 inches that were later bound into a leather-covered booklet. Before it was finished he showed it to me one Thursday evening, and I now have this treasure again in my hands. Illuminated and embellished with tail pieces and with two signatures of the ancestral Clarke, and with two well executed full-page line drawings of the New Hospital at Plymouth, Devon, and of the site of Lieutenant Clarke's house in Northampton, the three chapters and three appendices of the booklet are done in the style of composition and spelling of the early Colonial days, forming an interesting example of Clarke's painstaking care and artistic skill, wrought out for the eyes of his family only. It is entitled "A Fragment of the Life of Lieut. William Clarke, Puritan and Pioneer: An Early Member of the Massachusetts-Bay Colony settling on the Dorchester Plantation and afterward removing to Northampton. He lived an Honoured and Useful Life and founded a Large Family in a New World: To a few of his Descendants these pages are indited. The Tuyck, 1892." Much of what follows is taken from this booklet.

On the twentieth of March, 1630, there sailed from Plymouth, in Devon, the ship "Mary and John," a vessel of 400 tons, with 140 men and women of the East Anglian yeomanry, bound for the Charles River in the Colony of Massachusetts Bay. They were set ashore at Nantasket, now Hull, on the thirtieth of May, 1630, and shortly afterward most of them located at Dorchester Plantation, the second oldest settlement in the colony.

In this party was William Clarke, of pure English strain, although nothing further is now known of his ancestry. It is, however, the booklet adds, "fair to presume that the subject of this sketch was a young man of honour and probity, whose mind had been profoundly moved by the theological controversies of the age. . . . In his days he was a tiller of the soil, though withal a vigorous man of affairs."

There is no other record of William Clarke until June 23, 1636, when his name appears on the church records at Dorchester, together with that of his wife, Sarah, who was probably also of the "Mary and John" party. They lived at Dorchester for twenty-one years, tilling the land and raising a family of ten children. Then all of them moved to a newly arisen center that soon came to be known as Northampton.

The journey from Dorchester to the Connecticut Valley, made in 1659, was a plunge into an Indian-ridden wilderness. Mr. Clarke was then fifty years old, and made the way on foot, his wife riding horseback. "Panniers slung across the horse held each a baby, one the little William (whence our line is derived), the other the infant Sarah." The journey accomplished, Mr.

Clarke took possession of the twelve acres assigned him by the selectmen in the western part of the town on land which is now occupied by a part of the Smith College buildings. Here he built a log house, and later, on the river front, grist and saw mills, and here he lived for twenty years.

Life in the little settlement of some forty persons "was not only primitive and agricultural, but dangerous as well, for the savages did not treat these settlers with the uniform kindness shown to those at Dorchester, but their murderous onslaughts were disturbing and not infrequent. The town was at once obliged in self-defense to organize a military company, of which Mr. Clarke was chosen Lieutenant, the highest secular honour in the power of the little hamlet." Other honors came quickly, and for seventeen years he was representative at the General Court at Boston, and justice of the peace for a long period.

Lieutenant Clarke's descendants prospered, and the line of seven generations terminating in Noah Turner Clarke, the father of the subject of this sketch, was prolific, each generation furnishing about ten children. The line proceeds through five successive William Clarkes, spreading from Northampton to Lebanon and thence to Windsor in Connecticut.

William Clarke the fifth was a member of the Continental Congress, fought at Lexington and at Bennington, and after the Revolution moved by oxcart to the "Seneca Country," where he was one of the founders of Naples. It is interesting to make a slight digression here to note the cause for this migration. All of New York west of Seneca Lake originally belonged to Massachusetts, but she sold her rights to one million acres to Oliver Phelps and Nathaniel Gorham. They in turn sold these lands to the veterans of the Revolution, and to citizens of Massachusetts and Connecticut. Thus it came about, as Clarke says, that "these early villages were bits taken out of the Puritan atmosphere and set down in western New York," where Canandaigua and Geneva became "dignified centers of education and refinement."

The ninth child of William Clarke the fifth, born at Windsor in 1787, was Lorenzo Clarke, whose second child, born at Naples on April 8, 1817 (died 1898) was Noah Turner Clarke.

Noah Clarke married Laura Mason Merrill, and they had six children, of whom John Mason was the fifth.

In the booklet above referred to, Doctor Clarke writes further: "There was another man aboard the 'Mary and John' in whom we (I say this to my next of kin) have an equal interest. I mean Mr. (afterward Captain and Major) John Mason, some time resident of Dorchester, later the doughty fighter in the Pequot Wars." He soon moved to Windsor, as did the Clarkes, and from the family which he founded came Laura Mason Merrill, the mother of Doctor Clarke. Major Mason was born in England about 1600, came to this country, as we have seen, in 1630, played a prominent part in the struggle against the Pequot, founded the town of Norwich, Connecticut, and died there in 1672.

John Mason the second, we learn from data furnished by Noah T. Clarke, married in 1786 Sally Woodward, direct descendant in the fifth generation of Governor Bradford of Plymouth Colony and Alice Southworth, his wife. He had eleven children by Sally Woodward, of whom the fifth was Laura Mason, born at Castleton, Vermont, in 1796, and married in 1819 to Selah Higley Merrill, a lawyer of Castleton, son of Enos Merrill and of Delight Higley, a scion of the Brewster family of Plymouth. Mrs. Merrill died on July 9, 1820, four days after the birth of her daughter Laura. The child was brought up by her mother's sister, Altha Stevens Mason, who was the widow of Aaron Dana and who eventually went to live with the Clarke family at Canandaigua, dying there in 1880 at the age of eighty-six.

Another aunt, Sarah Mason, married Gideon Davison of Saratoga Springs, and Laura Merrill spent part of her girlhood in that village, going to school there. A third aunt, Margaret Fanning Mason, married Henry Howe, who became resident principal of Canandaigua Academy, and with this family the girl Laura resided later, going to school at the Ontario Female Seminary. In 1846 she was married to Noah Turner Clarke, then associate principal of the academy at Canandaigua. She died in that village on November 5, 1887, her husband and all her six children surviving her.

## YOUTH AND RISE INTO GEOLOGY

John Mason Clarke, the fifth in a family of six children, was born in the beautiful lake resort of Canandaigua, New York, on April 15, 1857. His father, Noah Turner Clarke, was for fifty years a teacher of science, and for nearly thirty years principal of the Canandaigua Academy. The boy John not only got his first schooling in the Academy building, but was actually born there, since his father did not begin to erect the Clarke homestead until 1858, and occupied it first in 1859.

Noah Clarke, at the age of twenty-one (1838), got his first experience in geology from James Hall's field assistant, Eben N. Horsford, who was born and raised in the Genesee Valley. "The latter found in Clarke a young school teacher of just his own age, a native of the place, interested in everything out of doors, and to him he appealed for guidance through the gullies and over the hills of the region. . . . The young schoolmaster afterward became a student in chemistry for one year under Horsford at Harvard" (Life of James Hall, p. 74). In 1870, Noah Clarke found a nest of early Upper Devonian crinoids, one of which Hall named after him (*Melocrinus clarkei*). The Clarke family, therefore, had long been interested in the geology of New York, in fact ever since the organization of the State Geological Survey by Governor Clinton.

Of Clarke's boyhood, his sister, Miss Clara Mason Clarke, has this to say:

> It seems to me John was always picking up "stones." When our home was built, the yard had just been filled in and "cowhorns" and "shells" were numerous. As a lad he used to trudge off with his bag and hammer to investigate some gully or lake shore. . . . He was particularly fortunate in finding trilobites, and my sharp-pointed black pins were greatly in demand for picking away the rock, so that the trilobite should stand out as it originally was.

His younger brother, Rev. L. Mason Clarke, adds:

> When he and I were not more than seven and five, respectively, we were interested in cutting out pictures of all sorts of animals which came with the big circus and menagerie posters, then in common use.

> We arranged them in match boxes, the long, old-fashioned blue ones, and tied the boxes with string and drew them along the hall floor as a procession, and John would learn all he could about the varieties and discourse more or less to me about them. He began his first "finds" in our old garden. John would hoe up spear and arrow heads. . . . He was always very sharp-eyed and could see something where I could not. . . . Of course Father was a good deal the same way and John found considerable encouragement from Dad, who as a surveyor was usually digging up something curious in the way of fossils. John was ever collecting; he had it in his system. . . . He always was a leader in what he undertook, even as a child. Born a Nature-enthusiast, yet even as a child he was always alert for other things.

Fortunately for us, Clarke himself wrote out the history of his earliest days, working on this at different times, particularly in 1904 and 1917. From this account we learn that shortly after his father moved into the new home a well was dug, and on the pile of Hamilton shales thrown out young Clarke collected his first fossils. He got in abundance "cowhorns" (cup corals) and "shells." He goes on to say:

> I can see now the blue paper match boxes which contained these treasures lying on the shelves of the closet off my sleeping room. Too young for a teacher or for an intelligent appreciation of these things, an instinct seemed to guide me in their acquisition, and after every ploughing of the large garden I forked over the soil searching for such fossils as the loose stone would afford, and over the gathered heaps of stone which had been brought together to clear the soil. I presume my blue boxes date back to a time when I was not more than seven years old, but I must have been ten when my father, who encouraged every impulse in me in this direction, put me in possession of Hugh Miller's writings and Hitchcock's "Text-book of Geology." The texts were too much for me, but the pictures in Hitchcock were an inspiration. In it on one page was the picture of a "Silurian trilobite," on another a "Devonian trilobite." My father's house was built on a high cellar wall made of large field stones, crystalline boulders and blocks of Coniferous limestone. The corner stones were of larger size and all of the latter kind, full of the fossil remains with which that rock abounds. I could never in later years get my father to remember, though clear enough to me even now, a day when I eagerly called him to one of these corner stones to show him where I had found a "Silurian trilobite" and a "Devonian trilobite" in the same block!

In 1923, in his eloquent "L'Île Percée," Clarke comes back to the Hugh Miller of his youth:

> Hugh Miller's books were my earliest guides in geology—I will not say inspiration, for some of them were pretty hard reading for a boy, but after all he made his odd fish rather attractive by his extraordinary descriptive powers and his trenchant English style. . . . My debt to him was a personal one.

To go back now to the 1904 account:

> In a desultory way as opportunity afforded between the later demands of school, and as the inspiration caught me, though laid aside at times, my interest in this collecting of fossils continued and became a productive pursuit as soon as I had learned how to make use of the volumes of the Paleontology of New York. [This was in the early seventies.] My home region was most beautifully supplied with the objects of my search, the shale cliffs along the shores and the ravines of the lake teemed with fossils, and I was in great measure solely a creature of my environment.

The region of Clarke's home is in the type area of the New York Devonian,

> the simplest, most lucid and most complete development of one great geological system, the Devonian, that the world has ever revealed. . . . The rocks of the country overflowed with fossils, often in beautiful preservation. They showed themselves in the stone fences and farm foundations; they lay loose along the streams and on the shores of the Finger Lakes; and they protruded from the rocks on the edges of the cliffs. So ubiquitous were they that the Seneca Indians used the fossil cup corals for pipes, strung together the joints of crinoid stems into necklaces, and buried brachiopod shells along with axes and spear points in the graves of their brave.
>
> Beside the daily strenuous demands of school these natural proclivities had no standing and were pushed into the background. But the break in the routine permitted me to indulge a growing interest in the mollusca of the region, and before leaving for college I had got together the mollusk fauna quite completely, both of lake, stream and woodland. When my good father sent me [1874] in turn to college at the cost of all he could get together, for there were four of us in succession, my zeal lay dormant or was for a while snowed under by the Latin and Greek and mathematics of the old-time course. I would not to-day surrender the little I have retained of the former for a good slice of my store of science. Not till I arrived at junior year and the course of gentlemanly and refined discourses on mineralogy by Professor C. U. Shepard in which the students were allowed to look at but not to handle specimens, did my suppressed love break out in full force.

In his "Sketch" of 1917, he says:

> Entering Amherst College in 1874, I fought bravely against the handicap of a poor preparation in Greek, warmed reasonably to my Latin, was dead in mathematics;. . . . it was not until I reached the courses in geology, mineralogy and zoology given by the distinguished Professor Benjamin K. Emerson, that my love for natural science, born long before, had a new birth. . . . Thus I got my start and left college [at the age of twenty years] with the class of 1877, the best of its kind.
>
> The first year out of college [1877-1878] was on the home ground, teaching in the Academy anything that came my way and diligently pursuing the study of the local geology. I had now become methodical. I collected from the Hamilton rocks with the greatest diligence and in profusion, plotting the vertical range of every species and these to the number of 300-400.

It was in this year that Clarke met D. Dana Luther, an amateur geologist living at Naples, of whom he goes on to say:

> Like interest in the mysteries of the rocks brought us together. One the staid, wise and cautious man, and the other a young, trained enthusiast. One had nothing else to do and both everything to learn. With his acquaintance came long summers together of excursions into all the rocks of western New York.

Continuing the discussion of his stratigraphic work, he says:

> On this basis I sought to establish a zonal division of these strata by faunules. . . . It was the first attempt of the kind, I think, on the Paleozoic rocks of New York, and though the homogeneous Hamilton shales did not well lend themselves to this effort, yet in a fair degree this end was obtained.

Clarke did not begin to publish these stratigraphic results until 1885. In the meantime, H. S. Williams had been appointed to the chair of geology at Cornell (1880) and his publications of 1881-1882 show that he also was studying fossil faunas as units for investigation in the Ithaca region. It therefore appears that these two paleontologists independently discovered the value of zonal stratigraphy, though Williams, who was ten years older than Clarke, got into print about three years earlier.

> In the autumn of 1878 I was called back to Amherst as assistant to Professor Emerson, and part of my work while there was to arrange the great C. U. Shepard collection of minerals which was next year destroyed by fire, and also the extensive C. B. Adams collection of Mollusca, out of which I culled an extensive familiarity with molluscan species and prided myself somewhat on the fact that I could then recognize and give the names of a thousand species at sight. While thus

engaged I wrote my first paper in a scientific journal (American Journal of Science) upon the discovery of a rare molluscan genus [Gundlachia] in western New York.

Now burning with the fires and fairly well along in my training, I returned to Canandaigua Academy for another year [1879-1880] of teaching and of geological work in the country side. My collections had grown to commanding proportions and ever crowded upon the space available for them in the old home.

In the autumn of 1880 I became teacher of science in the Utica Free Academy, succeeding the late George H. Williams, my collegemate and co-worker at Amherst in graduate work. Then in 1881-1882, on the recommendation of Professor Emerson, I was invited to go to Smith College as instructor in Geology, Mineralogy, Zoology and Botany. I demurred to the botany, and to the salary. Of the former I knew but little and the latter was no improvement on that in hand. The trustees met my objections most freely and thither I went. . . .

At my second year there I was made professor, and the end of this year [1883] I retired, having determined to wait no longer for my long hoped for experience in Germany. My withdrawal was regarded as temporary and with expectation on part of the president and myself of return.

In the summer of 1883 I went to Göttingen and joined Von Koenen, and returned in October, 1884. These days made history for me and will ever be filled with happiest recollections. I returned to Northampton to give the instruction in geology which had been cut down during my absence and the position curtailed by the establishment of a professorship of biology.

Just before Clarke was ready to return to America, I learn from his son Noah, he received a letter from President Seelye of Smith, accusing him of heterodoxy, and closing with the statement that Smith did not require his services longer. This was a direct violation of Clarke's agreement, but what was he to do under the circumstances? The change cut short his hopes of continuing his studies at Göttingen and of obtaining the doctor's degree in course. During the school year 1884-1885, therefore, Clarke gave instruction in geology, zoology, and German at the Massachusetts Agricultural College at Amherst. Then followed days of waiting at Canandaigua, where he continued to work on the Upper Devonian (mainly the Naples fauna), a study begun in the summer of 1877 and intended as his dissertation at Göttingen. Out of employment, he appealed for work to James Hall, whom he had known since 1875. His persistence was rewarded, through the strenuous assistance of a state senator, and on January 1, 1886, he became assistant to the man who was then the master paleontologist of the country.

Clarke's entry into Hall's service is described in his "Life of James Hall," as follows:

> In the autumn of 1885, I came to Albany partly to attend, so far as I might be permitted, a meeting of the National Academy of Sciences . . . but more particularly to show to Professor Hall and Mr. Beecher a quantity of new things in trilobite and crustacean lines which I had been extracting from the Devonian rocks in western New York. . . . The trilobites made so effective an appeal that I was to join the force at once and trust to good luck to edge my way into the service. On the first of January, 1886, nine o'clock in the morning found me in front of the great stove in Mr. Hall's "office" on the Beaverkill, trying to dry my soaked clothes after a rough tramp of two miles through a foot of freshly fallen snow. No one else was there; but presently the ruddy Santa Claus of Hall's figure coming in from breakfast appeared through the door, and with a gray look of surprise in his spectacles as he saw me by the stove, he said: "Oh, yes. How do you do? Could you lend me two dollars?" Then began my association of twelve years with this extraordinary man [then 79 years old] whom I had known slightly for ten years past but whose equations I had yet to learn.

The office assigned Clarke in the State Hall he occupied for twenty-five years, until he moved into the Education Building.

## MUSEUM CAREER

From January first, 1886, until his death in 1925, Clarke was connected with the Geological Survey of New York, rising to the position of State Paleontologist in 1898, and in 1904 to that of State Geologist and Paleontologist and Director of the State Museum and of the Science Division of the Education Department. From 1894 on, he was also professor of Geology and Mineralogy at the Rensselaer Polytechnic Institute in Troy. Of these appointments, that to the directorship of the Science Division was the most significant one in his life, since now he had not only inherited Hall's official mantle, but added a great deal more. As he says:

> This position involved not only the State Museum, but as well the research departments in Entomology, Botany, Zoology, and Archeology. My time had now to be divided between my special scientific interests and the creation of a new State Museum.

In 1907 and 1909, Clarke was also working toward a State Historical Museum, and his plan for it was distributed to all the historical societies in New York, and to others. Its growth was to come gradually through the present museum, and a beginning was made with Ethnology. Shortly afterward, a gift of $15,000 from Mrs. F. F. Thompson made possible the installation of the "Governor Myron H. Clark Museum of Iroquois Ethnology," now represented in the Museum by six large cases showing the family and religious life of these Indians in a manner unsurpassed elsewhere. In 1908 the Museum was made the keeper of all the wampums of the Iroquois Confederacy, and the director was given the title of Ho-san-na-ga-da, "Keeper of the Name."

The needs of the rapidly growing museum and of the other divisions of the University brought about the construction of the great Education Building, which was completed in 1913. In the autumn of that year, the Museum began to move into its new quarters, which occupied the entire upper floor, with 60,000 square feet of space. One-half of this space is devoted to Geology and Paleontology, an expansion that brought about an increase of staff and a modernization of the grand collections. The dedication of the building took place on December 29, 1916, before the assembled geologists of the country, who were addressed by Theodore Roosevelt. This was the proudest day in Clarke's life.

New York now has the best state museum in America, with the finest array of highly significant Paleozoic fossils. In invertebrate paleontology, it possesses one of the world's most valuable collections, containing upward of 7,000 type specimens, and constituting a mecca to which all students of the older Paleozoic go for inspiration and interpretation. Clarke also inaugurated the plan for the very artistic and lifelike restorations of Ordovician, Silurian, and Devonian marine assemblages of New York, now shown in the Museum, and this type of installation and teaching had its culmination in February, 1925, when he placed before the public a reproduction of the Gilboa Devonian forest, a living picture of the first flora to clothe Mother Earth. The creation of this attractive State Museum

Clarke regarded as his chief contribution to the civic and educational development of his state.

Clarke also planned and put into execution, with expert aid, the splendid volumes entitled "Birds of New York" and "Wild Flowers of New York," both of which have done great service to the people of the State, especially through their widely distributed cheaper editions. He established, with the support of the president of the University, the annual State Bird Day, and the annual courses of free public lectures given in the Museum.

Another service to the State which Clarke brought about was the acquisition of "unique or remarkable bits of geological scenery of high educational value . . . endangered by the progress of settlement or industry." He began this movement for the protection of natural monuments in 1908, and his first result came five years later with the gift by Mrs. J. B. Thacher of 350 acres to establish Indian Ladder Park, west of Albany, where the actual base of the Devonian can be studied to best advantage. Soon followed Lester Park, near Saratoga, showing in a striking way the Upper Cambrian algoid ledges; the Myron H. Clark Reservation, a glacial park near Syracuse, showing, among other effects of glaciation, the making of a wall over which dropped falls that were nearly as grand as Niagara; and the Starks Knob Reservation, near Schuylerville, with its long extinct volcano. There are now six of these parks or reservations under the administration of the New York State Museum.

Clarke dreamed of a yet greater state museum, a central one covering the entire field of museum interest within the scope of the State, with full supervising control of local museums. The statutory conception of a New York State Museum, he said in 1913, is "any public museum which the people of the State may choose to bring into existence, whether it be a museum of history, of art, of industry, or of education." It was, however, not to be a world or metropolitan museum, but one solely devoted to the things of the State. Clarke's plan for this great conception was completed in 1916, and presented to the assembled geologists at their Albany meeting, and in 1922 the Regents had received favorable consideration from the State

Roosevelt Memorial Commission. But his dream, when its fulfillment seemed almost at hand, was for the time set aside by the legislature of that year, when it voted two and one-half million dollars for a Roosevelt Memorial to be connected with the American Museum of Natural History in New York City. This act of the legislature broke Clarke's administrative spirit, and ever afterward he failed to show his former strength of planning and the dash so characteristic of him. As Walcott said in his memorial, "He felt most keenly and grieved to the end of his life that the effort to deprive the capital of the State of a great memorial to its former governor and foremost citizen of his time, Theodore Roosevelt, should have been successful."

## STATE SURVEY

While Clarke had charge of the Geological Survey of New York (1898-1925), with the aid of a competent staff nearly one-half of the State was geologically mapped on the scale of one mile to the inch, and the mineral wealth exploited. Summoning to his assistance the best experts available, and issuing their results in something like seventy bulletins, he brought the knowledge of New York geology, its rock structure, its marvelous fossil record, and its mineral industry to a condition that makes it safe to say that no equal area of 50,000 square miles in the world is so completely known and understood. Among those who did most of this work may be mentioned D. Dana Luther, James F. Kemp, H. P. Cushing, Rudolf Ruedemann, W. J. Miller, H. L. Fairchild, H. P. Whitlock, D. H. Newland, J. B. Woodworth, A. W. Grabau, G. H. Chadwick, and others.

## GASPESIA

No sketch of John M. Clarke, man or geologist, would be complete without recording the second great passion of his life, that for his beloved Gaspé. Attracted first to this far eastern portion of Quebec by the promise of geologic riches, he found besides a land of vivid beauty, discovered by Cartier in 1534, and peopled by fisher folk whose simplicity of living and traditions of hospitality spell peace to men weary of the strife of the market place. It was not strange, therefore, that he returned to Gaspé summer after summer, tramping its shores for three hundred miles, and living among the people of the coast, so that few knew the country, its human records, and its natural history, as he did. His interpretation of the geology is dealt with later in a discussion of his scientific work, but here we may pause to mention the two books in which his mastery of style finds itself at its best—both born of Gaspé. Few regions of the earth have had so ardent an interpreter, in whose pages the wonders of the geologic past, the marvelous beauty of land and sea, the stately days of the Seigneury, and the quaint customs of the present day mingle with equal warmth and color. "The Heart of Gaspé," published in 1913, and the even more charming "L'Île Percée" of ten years later constitute an important contribution to literature as well as to history and science.

In studying the history of Gaspé, Clarke helped to locate the site of the old French Customs House occupied by the Intendant, M. Revolte, and destroyed by Wolfe in 1758, and to dig out from the sands of the peninsula where it stood the relics of the old régime now in the Chateau de Ramezay. From Cap des Rosiers he took the Cartier medallion, and from Bonaventure Island he had the old freebooter Duval's cutlass with its gold plated brass mountings, and its beautiful damascened and inlaid blade, carrying the royal arms and the monogram of George III heavily worked into the hilt. Later he felt that the latter reminder of pioneer days should remain at Percé among the old families who knew the local history, and so he gave it to the leading merchant of the village, Mr. Charles Biard.

Clarke's interest in old china also found a new field in Gaspé, and, as he says, "led to the acquisition, at a time when no one else was interested, of a large collection of the old wares of the people." His publications on ceramics include "English Gold Lusters" and "the Swiss Influence on the Early Pennsylvania Slip Decorated Majolica," both privately printed at Albany in 1908.

Clarke actively concerned himself to arouse provincial and federal interest in the preservation of the waterfowl nesting places on Percé Rock, Bonaventure Island, and the Bird Rocks of the Magdalen Islands off Gaspé. He visited the Magdalens frequently, and wrote accounts of their geology and history. In recognition of his interest in Gaspé, the Quebec Board of Geographic Names in 1917 attached his name to a township covering the upper reaches and great salmon pools of the Grand Cascapedia River.

## OTHER PUBLIC ACTS

Clarke's strong historical sense is again seen in his placing of memorial tablets. This began in 1901, when he and a few of his associates placed on the home of Ebenezer Emmons on Hudson Avenue and High Street in Albany a tablet commemorating the fact that in this house in 1838-1839 was started the Association of American Geologists, the parent body of the American Association for the Advancement of Science. In 1908 he placed a tablet in Letchworth Park near the Portage cataracts on the upper Genesee to commemorate the first geologic work done by James Hall in western New York in 1839-1843. Five years later, through his efforts, Logan Park was set aside in Gaspé, and here he unveiled before the geologists of the Twelfth International Geological Congress a bronze tablet memorializing Sir William Logan's pioneer field work in eastern Canada. In 1916, at the meeting of the Association of American State Geologists, a memorial tablet was placed on Hall's private museum in Beaver (now Lincoln) Park in Albany. The grandest memorial of all, however, is to be unveiled this autumn (1928) in front of the old Albany Institute during the convocation of the University of the State of New York—a large bronze statue of Joseph Henry, the first secretary of the Smithsonian Institution, who was a native of Albany. Clarke started the movement for this memorial in 1916, raising $25,000, and he was to have made the unveiling speech.

Clarke was always much interested in the welfare of the city of Albany. Here he did much to rehabilitate the Albany Institute, one of the oldest scientific societies in the country, and was its president for many years. He was also president of both the Historical and Art societies, and they thrived greatly under his care, as did the Burns Club and the Walter Scott Memorial Association. He helped and cheered on the good work of the ladies of the Dana Natural History Society; was trustee of the Schuyler Mansion, and from 1916 on, of the Dudley Observatory. A member of the Fort Orange Council of the Boy Scouts, as well as of the National Council, he arranged for the Mayflower Medal to be awarded each year to the scout showing the best knowledge of the local history.

Clarke's championship of the need of preservation of scenic beauty was best exemplified in the case of Niagara Falls; as he so well says:

> The claim of the higher life, the demands of the finer emotions, the love for the beautiful in nature, express themselves in part in the government protection of natural wonders from defacement and destruction; in organizations created to keep alive this sentiment and extend the ægis of the State over natural glories which belong to mankind rather than to men. No wise man confesses himself devoid of such emotions. The violation of this principle in present practice offends the best sentiments of the race.

The "menace to Niagara" resulting from the desire of the power companies to utilize the falls, Clarke was one of the first to point out. The danger had long been threatening, and in 1904 the fight culminated in the New York Assembly. Clarke stood out against it, and in public addresses and otherwise pointed out that—

> The conservation of Niagara Falls is a question of public morals. About 800,000 tourists visit the Falls each year, and their number demonstrates how closely the interest of the whole world is focussed on Niagara, for these visitors are representatives of every nation. How many hundreds of thousands will seek out Niagara when the world learns that the Delilah of commerce has shorn it of its glory? Will they traverse the seas to behold the wonders of a breakfast-food factory, or any other industrial triumph? These are everywhere; Niagara is unique.

This battle, in which Clarke played so large a part, was won by the conservationists, and a treaty has been made with Great Britain, keeping the water of the Falls under reasonable control.

In 1902, Clarke was delegated by the Geological Society of America to represent that body at the dedication of a memorial to Hugh Miller, the Scotch quarryman, newspaperman, and geologist, who had been in some measure the inspiration of his youth, and for whose memorial—the Hugh Miller Museum at Cromarty—he had raised a considerable sum from the Scot's American admirers. At a later day, and as an appropriate cis-Atlantic memorial to Miller, Clarke proposed the name "Hugh Miller Cliffs" for the Devonian fish beds at Migouasha, a name accepted by the Quebec Geographic Board. Of these cliffs Clarke writes in "L'Île Percée":

> The Hugh Miller Cliffs are planted on French Catholic soil but their face looks sternly out over the river to Scotch Presbyterian New Brunswick. There one may stand on the shores where the salmon now run and from the rocks extract their odd, heavily armored ancestors, which might have died of their mongrel Greek names if a merciful nature had not put them to a kinder death. Among them was the magnificent Eusthenopteron (*pardi!*), which is as fine a salmon as the "Auld Red" ever produced. Hundreds of specimens of these ancient fishes have been taken from these rocks and thousands remain for him who will search them. My hammer never touched a rock with a more inspiriting impact than here. Fishing! At every "cast" of the weapon some fish rises, or mayhap a fern-leaf gets tangled in the tackle. And this is the sort of fish one can ship to his friends without hurry or ice; they will not spoil after their millions of years of storage.

## BIOGRAPHIES

With a strong historic turn of mind, it was but natural that Clarke should be an excellent biographer. This is only too apparent in the sketches which he has given us of G. H. Williams, G. B. Simpson, C. E. Beecher, J. C. K. Laflamme, R. P. Whitfield, N. H. Winchell, H. C. Hovey, C. S. Prosser, W. B. Clark, James Eights, H. P. Cushing, James Hall, and Archibald Geikie. The tribute to his old chief, published in 1921, a book of 565 pages, is in a class by itself. Hall was a youth of 25 years when he entered the service of New York and seven years past fourscore when that service ceased. In the biography, Clarke portrays "the man as he was; the influences that guided him and that he imparted; the work he did and the manner of doing it; the friendships he made and the esteem he won." Written in an animated style, eloquent in diction, replete with humor and anecdote, it shows us not only what manner of man Hall was and the tremendous amount of work he did, but also the men with whom he worked and those with whom he came into direct contact. It is, in fact, one of the two best contributions to the history of North American geology and paleontology, set in a background of these sciences in Europe. Reading it, we are forced to the conclusion that New York State truly has been the "mother of geologists." My review of this book in *Science* pleased Clarke, and he wrote me in one of his letters: "If you don't get your reward on this earth, I'll try to arrange matters with St. Peter so that we can sit together."

## HONORS

Of "honors which beautify and crown success," Clarke had many. Four times he was called by leading universities to take their chairs in geology, and each time with a better salary than he received at Albany (Ohio State 1898, Columbia 1900, Yale 1904, and Pennsylvania 1919), but each time he declined, saying that his work was in New York. To his own commonwealth he gave his best as a loyal son, and he was deeply grateful for the liberal support that she gave him in return, as appears again and again in his annual reports to his superior officers.

Clarke was elected to something like fifty scientific and historical societies in this country, Canada, England, Germany, France, and Russia; made an Immortal in the National Academy of Sciences in 1909; elected to membership in the American Philosophical Society, the American Academy of Arts and Sciences, the Geological Society of London, the Authors' Club of London, the Société Russe de Minéralogie. He was vice-president of the Geological Society of America in 1909, and its president seven years later; first president of the Paleontological Society in 1909; received the Prix de Léonide Spindiaroff of the International Geological Congress in 1910 for his work in Gaspé, a gold medal from the Permanent Wild Life Protection Fund in 1920, the Hayden Gold medal of the Philadelphia Academy of Natural Sciences for excellence in geological research in 1908, and the Thompson Gold Medal of the National Academy of Sciences the month before his death.

Of honorary degrees he also had many. Most signal of these, in his own opinion, was the honorary Ph. D. conferred upon him by the University of Marburg in 1898, "done without my knowledge and done so rarely that not half a dozen such degrees are conferred annually by all the German universities together. At the time it was given no American known to me and none now [1904] bears the same degree." Colgate gave him an honorary Sc. D. in 1909, Chicago in 1916, and Princeton in 1919. From his Alma Mater he received the LL. D. in 1892, and from Johns Hopkins in 1915. To all these honors was to have been added another, since letters from Professor Barrois of Lille state that he was to have been made a fellow of the French Academy at its next annual meeting.

## *PUBLISHED WORK*

### PALEONTOLOGY AND MORPHOLOGY

After five summers' work in the field, Clarke began to show results, and his first three papers in a scientific journal appeared in 1882 during his professorship at Smith. They have to do with a new species of the living mollusc Gundlachia, and with rare specimens of Crustacea—phyllocarids and barnacles—from the New York Devonian. Arthropods were, therefore, his first love among fossils, and they continued all through his life to have for him a dominating interest. In these early papers he bursts upon the scientific world, as it were, as a full-fledged descriptive paleontologist, since they show nothing of the beginner; even then he wrote in a clear and direct fashion which, however, as yet displayed none of the phrase-making, quaintness, love of strange words, and power of embellishment so characteristic of his later writings.

With Clarke's appointment to the New York Survey, his career as a paleontologist and stratigrapher was assured, and from his head and hand there came a continuous stream of the best kind of geologic publications, the great bulk of which have to do with the Devonian and were issued by his native state.

His complete bibliography contains 452 titles, and of these about 300 are of a paleontologic or geologic nature, exclusive of the 76 reviews in the same fields. Together his printed books and papers cover over 10,000 pages, in which he is godfather to 135 new genera and at least 870 new forms; how many species of fossils he studied will probably never be tabulated. At least 3 genera and 42 species are named after him.

Clarke was born on Devonian rocks, and they ever remained the magnet of his endeavors. "The work of a geologist is preeminently what his environment makes it." The strongest pulls were those exerted by New York and southeastern Quebec, but he was also attracted by the Devonian of South America, Germany, and Maryland. Probably three-fourths or more of his total output has to do with the paleontology, stratigraphy, and mapping of this period. He long ago became one of the two greatest world authorities on Devonian, the other being Emanuel Kayser of Marburg and Munich, who has also passed away since this memoir was written. Clarke's study of the Upper Devonian faunas of Iberg, Germany, was written at Göttingen while a student of Von Koenen, and it was at this time that he became acquainted with Kayser. His loyalty to these two teachers of his is shown in his contributions to their Festschriften: "Evidences of a Coblenzian Invasion in the Devonic of eastern North America" to that of Von Koenen in 1907, and to that of Kayser in 1915, "Conceptions regarding the American Devonic."

### BRACHIOPODA

Shortly after Clarke got to Albany (1886), he became deeply interested in some work that Beecher was then doing. It appears that in 1878-1879 C. D. Walcott made extensive collections for the New York State Survey at the famous Silurian locality in Waldron, Indiana, sending Hall about seven tons of fossils and slabs. In washing this material Beecher saved all the freed dirt and so got together a large quantity of minute specimens. He and Clarke, working by lamplight night after night during the years 1886-1887, picked out of these washings about 50,000 baby brachiopods, with lengths ranging from less than 1 up to 5 millimeters. Finally, they culled out 15,000 good examples which they separated into twenty species, each abundantly represented by specimens. Arranging these in growth or ontogenetic series, they then worked out the appearance of the specific characters. Their results are set forth in "The Development of some Silurian Brachiopoda" (1889). This was probably the first ontogenetic work on fossil brachiopods, and while of an elementary nature, it prepared both authors for a better appreciation of their later studies on this class of organisms. Probably the most striking result was that the inceptive shells, of whatever species, were smooth, only slightly convex, and had a subcircular outline. This led Beecher later on to the discovery that all brachiopods start in life with this kind of shell, which he called the protegulum, and since the nearest fossil mature forms are of the genus Paterina (Iphidea), he called the protegulum the Paterina growth-stage.

When Clarke had completed the work on the Devonian Crustacea in 1888 (see page 208), Hall wanted him to take up a revision of the species of the Paleozoic Brachiopoda, but the young man had in mind a greater and more philosophic scheme. Their joint planning resulted in a turning away from a study of fossil faunas to a generic one having also to do with the phylogeny and evolution of an entire class. It was in search of material for this work that Hall came to Cincinnati in the summer of 1889, and seeing my large and well identified collection of brachiopods, proposed that I come to Albany as his private assistant, and allow him the use of my private collection—an arrangement that lasted for nearly two and a half years.

Our joint labors resulted in the work entitled "An Introduction to the Study of the Genera of Paleozoic Brachiopoda," by Hall and Clarke, which appeared in 1892 and 1894. In this memoir of 760 pages and about 90 plates, better known as "Paleontology of New York, Volume VIII," 180 old genera are redefined and 58 new ones added, while as a by-product came the description of 57 new species. While the books were in press, the study was extended to a synoptic revision of all the brachiopod genera, living and extinct, along with a summation of the known anatomy of the soft parts in the living species, and their bathymetric and geographic distribution; it appeared in two octavo volumes under the title "An Introduction to the Study of the Brachiopoda, intended as a Hand-book for the Use of Students," the two parts being issued in 1892 and 1894, respectively. This reworking showed that the class had at least 325 genera and subgenera worthy of recognition. The four books, treating of a group of organisms that has lived since at least the beginning of Cambrian time, form the most comprehensive study ever made of a class of invertebrate fossils, and represent one of Clarke's highest attainments in morphologic and phylogenetic work. Due largely to their stimulus, researches on these organisms throughout the world have resulted in the recognition of almost 700 genera of brachiopods.

## CRUSTACEA

When Clarke began his official work under Hall in 1886, he was set to work on his pets, the Crustacea. This study resulted in the memoir usually known as "Devonian Crustacea" (Paleontology of New York, Volume VII, 1888, by Hall and Clarke). In this volume, which included much new material that Clarke had collected in his earlier years and had brought with him from his home, are described 144 species (50 new) in 28 genera (9 new). Of these, 127 species are of the Devonian, 83 forms in 10 genera being of Trilobita. Among them are highly ornate and gigantic forms, the last of a rapidly declining stock. The xiphosurans are represented by 1 species, the eurypterids by 3, phyllocarids by 26 species in 8 genera, decapods by 1, phyllopods by 2, and cirripeds by 11 in 4 genera. Of this volume Clarke said in 1921:

> This book on the Crustacea was a substantial descriptive work which has served well, but it attempted nothing serious in the way of classification; it did, however, establish some interesting facts in development or ontogeny.

## SPONGES

Finally came what may be regarded as the concluding volume in the series known as "Paleontology of New York." This was "A Memoir on the Paleozoic Reticulate Sponges constituting the Family Dictyospongidæ," by Hall and Clarke (1898-1899). Here are described and figured all the late Devonian and Mississippian forms of "glass sponges," of which there are 128 species. It is mainly in New York that the great fossil "sponge plantations" occur. Of new subfamilies there are 7, of new genera 22, and of new species 75, and the whole forms the most elaborated study ever made of Paleozoic sponges.

### EURYPTERIDA

The most detailed morphologic, ontogenetic, and phylogenetic study of fossils made by Clarke is the joint memoir with Ruedemann on the eurypterids of New York (1912). It is only locally that these fossils are common and yet thousands of specimens were assembled, probably more than had ever before been brought together, with the result that North America was seen to have 62 species (26 are new), and 46 of these occur in New York. No locality in America ever yielded more material of this interesting group than that in the Silurian (Bertie) at Buffalo. They ranged from the Upper Cambrian into the early Permian, and were marine animals into the Silurian. Then they became euryhaline or able to live in both salt and brackish water, and finally throughout the Devonian and Carboniferous they were small and scarce animals that lived wholly in fresh water. "Some were best adapted to swimming, others to crawling and many to finding their food by grubbing in the mud."

Clarke and Ruedemann had specimens as small as 2 millimeters in length, and the ontogeny of the Eurypterida was shown to agree with that in *Limulus*. Neither line had any direct relationship with the trilobites, and their origin probably goes back to the Proterozoic, the trilobite-crustacean and arachnid lines doubtless having independent origins in chætopod annelids. The order Eurypterida was here divided into Eurypteridæ and Pterygotidæ.

## PALEONTOLOGY AND STRATIGRAPHY

### SILURIAN-DEVONIAN BOUNDARY

While Clarke was a student in Germany, a lively discussion was going on, centering about Professor Kayser, who had in

1878, 1881, and 1884 raised the question as to the actual boundary between the Silurian and Devonian. The founder of these terms, Murchison, had established neither a top for the one nor a base for the other. In 1889 Clarke spoke to me about the "Hercynfrage," saying that he was writing an account of it, and that, as he saw it, the Lower Helderberg was the base of the Devonian in America. But how to get this paper by our watchful chief, with his quite different views? Long afterward (1915) Clarke wrote:

> Hall was so absolutely hostile to the suggested interpretation that in order to even secure publication for this array of evidence, it became necessary to change a possible argument into a neutral statement of facts, and all conclusions into queries.

Hall published the paper, however, in 1889 and I was converted to Clarke's view, namely, that the lower Pentamerus limestone (= Coeymans), and not the Oriskany, as had long been held by Hall and Verneuil, was the base of the Devonian system of rocks. Clarke returned to the discussion in 1891 and 1894 (review of Tschernyschew's "Fauna d. unteren Devon," 1893), holding "that the fauna of the Helderberg division is not Silurian is demonstrated." It was not until 1900 that I got a chance to take a stand on the question in print, and my paper in the *Bulletin* of the Geological Society of America led to another controversy, with Clarke and Schuchert on one side, and Henry Shaler Williams on the other, and it was as a result of this discussion that the two former went to Gaspé, as will be seen further on. The storm clouds have, however, long since blown away, and the Coeymans is accepted as the base of the Devonian on this side of the water. The boundary in continental Europe is now also adjusted on this basis, but in Great Britain, where the Devonian system started, the older geologists are still trying to adjust themselves to the views of the rising generation, namely, that the Ludlow closes the Silurian, and that what is above is Devonian.

### ORISKANY FAUNA

In 1892 Beecher found on Becraft Mountain, near Hudson, New York, a new locality for the Oriskany fauna, and one far more varied than any heretofore known in that State. This discovery Clarke elaborated, and published his conclusions in 1900 in the memoir "The Oriskany Fauna of Becraft Mountain, Columbia County, N. Y." Here are described 113 species, 31 being new. About one-fourth of the fauna is from the Helderbergian below, and ten forms go into the Middle Devonian. The faunal characteristics of the Helderbergian are also analyzed, with the result that everything from the base of the Coeymans up is definitely referred to the Devonian, while a review of the Manlius biota shows that it is still clearly of the Silurian.

### GUELPH FAUNA

Until 1903, it was not known to what extent the Guelph faunas occurred in the Lockport limestone of New York. In that year a great deal of material, brought together by several collectors, was elaborated in the memoir by Clarke and Ruedemann entitled "Guelph Fauna in the State of New York." Here it is shown that the Lockport contains two distinct faunas, an older one, the outgrowth of the Rochester below, and the Guelph, which pulsates two or three times from elsewhere into the upper part of the Lockport. This recurrent Guelph fauna has 71 species in New York, and of these the memoir describes 14 as new. It is a fauna composed dominantly of thick-shelled molluscs and some brachiopods, which lived in a shallowing and vanishing, warm and dolomite-making sea, surcharged with salts. The authors trace the extent of this seaway and conclude that the fauna is of northern origin.

### DEVONIAN OF GASPÉ

As was said above, in 1900 I had become involved in a controversy with Williams as to the lower boundary of the Devonian, while Clarke a few years earlier had assembled Oriskanian fossils from beds in northern Maine that were said to be Silurian by Williams. Both of us had read the work of Logan and Billings ("Geology of Canada," 1863) on the very long "Siluro-Devonian" section of Gaspé Peninsula in Quebec, where the Silurian was said to pass unbroken into the Devonian. We therefore arranged to see this wonderful record during that summer. Together we first visited the coast of Arisaig, Nova Scotia, then that of Dalhousie, New Brunswick, where Clarke became interested, and this interest grew as we went on to Percé in Quebec, and finally to Gaspé. We then agreed to divide the work between us, Clarke to take the Oriskany equivalents, and I the Helderbergian and Arisaig faunas. In the end, however, Clarke worked out the whole of this Devonian, since there is no Silurian involved in the Gaspé section, while my students and I described the Arisaig Silurian sequence and its faunas.

On this trip of 1900, Clarke told me that he had found in Gaspé what he had long been looking for—a land of quaintness that reminded him of Scotland and the Old Red, both lands of red sandstones and of fish, fossil and recent, reawakening in him memories of his boyhood days and his reading of Hugh Miller's popular books. To this part of the Maritime Provinces, therefore, Clarke returned nearly every summer, and became the high priest of its geology. From 1900 on, he published at least fifteen papers and books on the paleontology and geology of the region, preëminent among which stands his magnum opus, "Early Devonic History of New York and Eastern North America" (1908-1909). These two quarto volumes, comprising upward of 600 pages and 100 plates, treat of the Lower Devonian stratigraphy and faunas of Quebec, New Brunswick, and Maine, fitted into the older background of the equivalent formations of New York and the Appalachian geosyncline. In this faunal study he was concerned with more than 700 species and described about 450, of which 160 were new. We do not see here that degree of paleontologic refinement shown in his study of the Naples fauna, but the stratigraphy and geologic structure of eastern Canada are far more difficult than those of central New York, and, moreover, he was dealing with Lower Devonian faunas and intricate seaways throughout a spread of about 1,500 miles. And even this was not all, for the faunas were also seen against the background of those of western Europe.

Clarke concluded that during Helderbergian and Oriskanian times the Gaspé seas were generating faunal centers that dispersed their life southwestward through the St. Lawrence trough, but that in Hamilton time the migration was reversed.

The Gaspé sequence of strata, as defined by Logan, has 2,000 feet of limestones, divided into eight divisions, and followed by about 7,000 feet of sandstones. The two basal divisions have come to be known as the St. Alban limestone (160 feet thick with a fauna of 51 species), which is followed by the poorly fossiliferous divisions 3 to 6, now called the Cape Bon Ami limestone (1,050 feet, with 11 species), and then by divisions 7 and 8 = Grande Greve limestone (800 feet with 150 forms). The St. Alban series correlates with the Coeymans and New Scotland of New York, while the Grande Greve is mainly Oriskany with some Onondaga. The overlying Gaspé sandstones have, about 1,000 feet above their base, an unmistakable Hamilton fauna (having 48 species of which 14 are new), but higher the fossils are scattering land plants and fishes that do not as yet give the exact age of the higher strata of this thick sandstone sequence, other than that they are Upper Devonian. Then followed intense mountain making—the Acadian Revolution which was succeeded by the accumulation of the Bonaventure land conglomerates to depths ranging up to 1,500 feet in the structural valleys now occupied by the Bay de Chaleur.

All in all, "Early Devonic History of New York and Eastern North America" is not only Clarke's master work, but also one of the most comprehensive faunal studies that we have in America, and shows Clarke to have been among the world's best stratigraphers.

## NAPLES FAUNA

As Clarke was intending to go to Germany for a doctorate after he should be graduated from Amherst, he began in the year of his graduation (1877) thinking about subject matter for his dissertation. The Portage group had been thought to be very poor in fossils, but as he and D. D. Luther had found many of them in strata of this age, Clarke concluded to take up a detailed study of the group and its contained faunules. As we have seen earlier in this paper, his plans for a degree in course in Germany did not come to fruition, and it was not until 1898 that the finished results of his study on the Naples fauna began to appear, and part 2 of the final report was delayed until 1904. In the meantime he had written sixteen other papers on this stratigraphic unit and its faunules. One of these has a great deal of stratal detail not in the two final papers, and this should be borne in mind by the student; it is entitled "The Stratigraphic and Faunal Relations of the Oneonta Sandstones and Shales, the Ithaca and the Portage Groups in Central New York" (1897). In Clarke's "Naples Fauna" we have one of his two best memoirs on faunal and stratigraphic studies, and it is one of the finest examples that a worker in similar fields can set before himself as an ideal to be attained.

The Naples fauna is characterized by *Manticoceras intumescens,* which occurs throughout the 600 feet of strata situated near the base of the Upper Devonian. It is a part of the Portage group, and occurs in two facies—black shales and sandstones—which alternate with one another several times. In eastern New York lay land, while to the west was deepest water, and the typical Naples fauna becomes disentangled from the shore faunas at the meridian of Cayuga, but fails to be present at the west end of the State. It is a distinct biota occurring only in the Genesee province of New York, while farther east is first the Ithaca and then the Oneonta province. The life is peculiar in that it is chiefly of the floating and swimming types, in the main bivalves (cardioconchs and Lunulicardia), cephalopods (mainly goniatites), and gastropods and pteropods. In all there are 153 species, as follows: pelecypods, 72 forms (52 new); cephalopods, 37 (25 new); gastropods, 26 (14 new); brachiopods, 7; and scattering, 11. The work yielded 37 new genera. Clarke says that the warm-water element, the Styliolina faunules, came in from the south, while the main part, with the goniatites, came in from the northwest in a colder water that "laved the northern and eastern shores" of the Appalachian gulf; and that "the proximal path of its migration lies buried beneath Lake Erie." Finally, that at least the goniatite elements of the Naples fauna had their origin in Timan (arctic Siberia), spread thence down the Cordilleran geosyncline into the Genesee province and from there eastward to Europe. That there is this direct European linkage with the "intumescens fauna" is seen in 18 species in common with the Genesee province, along with at least 19 others having close relationships.

## ZONES

Clarke was careful in his studies of faunas to note their differences and to attach definite values to them. For instance, a hemera (Buckman) is the time duration of a guide fossil like *Manticoceras intumescens,* while a zoehemera (Clarke 1898, "Naples Fauna") specifies the duration of a particular faunal province like that of the Naples fauna of western New York. A prenuncial fauna (Clarke 1898) is a heralding assemblage of a later, more fully developed fauna, as the Styliolina assemblage in the Genesee is prenuncial to the Naples one. The meaning of sequential faunas (Clarke 1898) is self-evident. On the other hand, an indigene fauna (Clarke 1902) is "one which, taking possession of the marine province at an early date, held the ground (subject to variations in its species combination) for a long period, during which may have occurred various minor invasions. . . . Every indigene fauna is alien in its inception."

## EVIDENCE OF ICE IN UPPER DEVONIAN TIME

As long ago as 1843, Hall found in the Portage formation of New York grooved and striated surfaces on sandstones that in their courses are "as unbroken as in the glacial or alluvial scratches upon the surface of the present rocky strata." He could not explain these and other surface characters like "mud flows" and *"Fucoides graphica"* (regarded as seaweeds), and they have puzzled all who have seen them. Clarke had noted these markings since his college days, but not until he wrote "Strand and Undertow Markings" in 1918 (1917) did he attempt to explain them. He then said that the "mud flows" were due to the rilling of water running down a flattened beach slope, and that some of the striations were made by floating algae dragging over the bottom, but that most of the groovings and striations were due to moving shore ice, and that the *Fucoides graphica* were the filled holes made by ice crystals growing in the bottom muds through the formation of ground-ice. "There is then reason for inferring that the late Devonian was a period of cold . . . and may well have created conditions . . . which would give plenty of means for channeling the Devonian strands of New York, by the movement of land ice toward the sea or by the landward thrust of the sea ice back from the water." *Fucoides graphica,* however, is now regarded as the burrow of a marine annelid (see Amer. Jour. Sci. (5), vol. 14, 1927, p. 159).

In the Portage at Ithaca, H. S. Williams was attracted in 1881 to "channel fillings," which channels, he explained, "were caused by the scratching of icebergs on the shoals represented by the interbedding shales." He, like Hall before him, noted that these channels and groovings strike east and west. These are interesting explanations, and, if true, must find corroborative evidence elsewhere. In "L'Île Percée" (1923), Clarke restates the evidence advanced several times before that beneath the fish beds of Upper Devonian age at the Hugh Miller Cliffs in Quebec, many of the boulders "are scored and nicked, polished and glazed, and some show without doubt the scratches and striations which could hardly have been made in any other way than by a movement on each other within a sheet of land ice. . . . Here is, then, the evidence of land ice over Gaspé at a time following immediately upon the great continental elevations which took place toward the close of the Middle Devonian."

### DEVONIAN-CARBONIFEROUS BOUNDARY

Regarding the upper boundary of the Devonian, Clarke expresses himself fully in "Construction of the Olean Rock Section" (1903). The Carboniferous fossils, he says, appear at the base of the Cattaraugus in the Wolf Creek conglomerate, and it is in fossils that we have "the support of the most direct evidence." Disconformities in horizontal strata may be more apparent than real, since in the Upper Devonian "sand reefs constantly display indications of deep decapitation due to shifting of bars and change of direction of currents, or a modification by heavy tidal flow on a shelving coast. Unconformities thus frequently exist which are no indication of unrecorded time." This short paper states clearly what should be the criteria in drawing boundary planes "in sediments characterized by the uniformity of their succession."

### THE NEW YORK DEVONIAN AS A WORLD STANDARD

Finally, what the New York Devonian means in the setting of this period throughout the Americas and Europe, Clarke presents in a paper that he wrote as a tribute to the great *Devonkenner* of Europe, Professor Emanuel Kayser, on his seventieth birthday. The standard of reference throughout the world, he here shows, should be the Devonian of the State of New York, since the latter "is very properly designated a Devonic state, for more than one-half its area is covered by the rocks of the period, and the succession of its members from base to summit comprises a record whose pages are almost intact and effectively illustrate the variant happenings of the time." "Not in Devonshire nor in the Rhineland, not in the Urals nor in Siberia, not in the Bosporus or in South Africa, not in the basin of the Amazon, of the La Plata or in the Andean Cordilleras, is the full and variant succession of Devonic events so well recorded or at least so clearly and simply presented, and perhaps so fully known, as in New York."

### DEVONIAN OF SOUTH AMERICA

A few years after Clarke joined the New York State Survey, his friend, Orville A. Derby, of the Brazilian Geological Survey, who was also a New Yorker by birth, asked him to describe certain Silurian and Devonian fossils. This beginning led to eleven publications between 1890 and 1919, totaling some 600 pages and 37 plates of fossils, and describing 260 species, of which 131 are new, along with 14 new genera. Of these forms, 21 (16 new) are Silurian, all the rest being of the Lower and Middle Devonian. "Fosseis Devonianos do Paraná" (1913) brings together all that is known of the Devonian faunas in South America and Falkland. The Silurian and Devonian of the Amazon region are of one faunal province and have relationships with North America, while the Lower Devonian ones of southern Brazil, the Andes, and Falkland are of the austral province and distinctly linked with South Africa. These works show that Clarke put into order and brought up to date the whole of the Devonian faunas of South America. With them, and with his far more extensive studies of the Devonian of the Appalachian geosyncline, we are now able to understand the relationships of the Devonian of the New World to that of Europe, Asia, and Africa.

## THE PHILOSOPHY OF CLARKE THE PALEONTOLOGIST

The philosophy which Clarke derived from his paleontologic studies is to be found mainly in five of his papers, namely, his address to the Paleontological Society as its first president in 1910 (1911); "The Philosophy of Geology and the Order of the State," being the presidential address to the Geological Society of America in 1916 (1917); "Postbellum Reflections on the Place of Paleontology among the Sciences" (1920); "Organic Dependence and Disease," published in 1919 and 1921; and "The Age of the Earth from the Paleontological Viewpoint," read before the American Philosophical Society in 1922. His conception of what the life of the past should mean to the living human world may be summed up as follows:

> The pursuit of science does not, alas, raise a man to the practice of a higher morality and it has no power to enlarge the soul of the man whose concern therein is only the acquisition of new information.
>
> Paleontology is . . . the most far-reaching of all the sciences. In it lies the root of all truth, out of it must come the solution of the complex enigmas of human society. . . . It is the panoramic display of the life of the ages, the expression of the organic law of a hundred successive worlds.
>
> I regard as peculiarly a doctrine of paleontology that of recapitulation . . . the fact that each individual carries in himself and his develop-

ment history, the history of the race to which he belongs, however accelerated or however retarded it may be.

The problem as to how species have originated . . . does not belong to paleontology. Students, both of living organisms and of fossil ones see the engrossing fact of evolution, but see it out of different eyes; the former perhaps as one would see a vast throng gathered together to acclaim a momentous event, a great victory or a high armistice; the latter as an endless army marching by, its vanguard already out of sight in the mists of the horizon, stragglers along the way falling back or giving up in hopelessness, while the interminable procession ever emerges out of the shadow.

The mutation is a clearly recognizable entity in paleontology, is the bridge crossing from species to species, the connecting link which establishes the continuity of the chain. . . . The mutation is the departure from the one, seeking adjustment and failing, or seeking and finding it in what must be recognized from accepted standards as a distinct specific form, a different species from its parentage.

The standards of our best civilization are not those which have been derived from a clear apprehension of the paramount law, [the biologic law. On the other hand, reflecting man has] some notion of how short is the way he has traveled toward excellence and how long the road that lies ahead. . . . The physical man is an item in the scheme of life . . . but it is the most compelling fact of existence that we are that item.

[All animals in Nature are born free, but not all are] born to an equality of opportunity. . . . Equality of opportunity in paleontology and in human history would mean a world of life with the chief factors of evolution eliminated. . . . If there had been equality of opportunity through the ages of paleontologic history there would be no men in the world today.

The greatest significance of evolving life as seen throughout the geologic ages came to Clarke from his studies of the earliest phases of the parasitic or dependent conditions of life—a study of mutual organic associations that lead to commensalism, sessility, and finally to parasitism. The degenerate modes of life involve

the essential abandonment of normal direct upright living and the benefactors thereby are types of life which Nature has cast out and aside as hopeless. . . . Individual and locomotive independence then, it would seem, has been the major function and prime determining factor in the progress of life. . . . All progress in life, as reckoned in terms of man, has come through independence and through those lines of animal life in which independence has been maintained at any cost. . . . Rescue of dependents is therefore not a part of the scheme of Nature, except through the exercise of intelligence.

The paleontologist, looking at the record of life on the earth, says to the State:

> Be intelligently guided in the treatment of hereditary community parasites, defectives, congenital or confirmed misdemeanants, whatever the form of degeneration may be, by recognition of the presumption that in so far as they can not be physiologically corrected, they are abandoned types in which there lies little hope of repair.
>
> Nature makes for the individual. . . . This truth is registered on the tablets of the race. . . . Over and over again the dominant race has started on its career as an insignificant minority struggling for its existence against an overburden of mechanical and vital obstacles, armed only with specific virtues which have little by little fought their way into the foreground, and by so doing consummated their upward purpose. . . . The majority is purely numerical, while wisdom and truth may rest with the minority. . . . The voice of the people is not the voice of God. Nature's fundamental laws can not be applied. They apply themselves; they govern without consent. . . . The law is of God, the standard of man.
>
> The simple life . . . is the life which really endures. I mean by that it is the life which is ever entering slowly into something better, through sons and daughters born and to be born, and ever leaves a greater share behind it as simple as at the start. The starting point must always endure, the seed must remain if the fruitage is to continue. We are taught to-day the immortality of the simple. . . . For the vast majority of mankind must always be of simple mind, intent upon the simple and material things of life. . . . Of poets and prophets, of men of letters and seers of science, there must always be few and they are not likely to be understood or appreciated in their own day, though they have stood guard over the jewel casket of the race ("L'Île Percée," 1923).

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Of the English yeomanry, and among the first to enter through Massachusetts Bay to humanize the wilderness of America, the ancestors of John Mason Clarke followed the path of empire westward for three centuries, until, settling at Canandaigua, they gave rise to a teacher of the plain people in Noah Turner Clarke. Never bounteously blessed with the goods of this world, but rich in lofty ideals, he raised a family of leaders, and among them one of the greatest paleontologists of our time, a builder of museums, and a statesman of science.

Always a loyal son of New York, Clarke brought to the highest excellence the knowledge of its incomparable Devonian, and ever maintained the New York sequence of Paleozoic formations as the standard of comparison for eastern North America, and in general terms for all the world. But it would be a great mistake to think that his vision was limited to the Empire State, for his work in South America and above all in his beloved Gaspesia was no less significant than that in the land of his nativity. In Quebec also, as well as in New York, he was not only paleontologist and geologist, but preserver of scenic beauty and of wild life, recorder of pioneer work in commemorative tablets, and historian of early days.

Clarke's period of descriptive and faunal work attained its climax in 1908 to 1909, with the publication of his greatest memoir, "Early Devonic History of New York and Eastern North America," and during these protracted studies he was laying deeply the foundations of his belief as to what paleontology should mean in man's speculations concerning himself and his relation to the web of nature. Between 1908 and 1922, his philosophic period, he formulated these conclusions, the gist of which is that we are born free but not equal in ability or opportunity, that socialism and communism do not lead to the growth of the intellect, that all forms of human degeneracy should be carefully guarded by the State, and that the few seekers after knowledge, the guardians of the "jewel casket of the race," must ever be ready to sacrifice themselves for the uplift of the majority, who are leading the simple life, "the life that endures," though spiritually growing through slow accretion.

An intimate knowledge of the life of John Mason Clarke reveals that his path to eminence was hewn out with much labor, taxing to the full the many-sided training that was his from home, college, and environment. Gifted with marked intellectual powers, he used his talents to the full, steadily rising as paleontologist and stratigrapher, as museum administrator, as philosopher and historian. Above all, his life stands out as one of continuous service, service to his family and State, to paleontology and Devonian lore, and to Gaspé, "Coast of the Mountain Ends."

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[1] Clarke wrote many reviews (76), most of which appeared, sometimes unsigned, in the *American Geologist* between the years 1893 and 1897, but only a few of the more important of these are included in the list below.

NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA

BIOGRAPHICAL MEMOIRS
VOLUME XIII—THIRD MEMOIR

# BIOGRAPHICAL MEMOIR

OF

# EDWARD DRINKER COPE
## 1840-1897

BY

HENRY FAIRFIELD OSBORN

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1929

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1930

E. D. Cope

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# LETTER OF TRANSMISSION

January the thirtieth,
Nineteen hundred twenty-nine

Edward Drinker Cope, one of the greatest palaeontologists and anatomists America has produced, died on April 12, 1897. Sometime before his death his secretary, Miss Anna M. Brown, had begun work upon his extraordinarily extensive and difficult bibliography. These materials passed into my hands together with a nearly complete set of Cope's writings and his two great collections of fossil vertebrates, including fishes, birds, reptiles and mammals, now in the American Museum of Natural History. Under my direction the bibliography was completely revised by Miss Jannette May Lucas and extensive scientific annotations were made by Dr. William Diller Matthew, Dr. W. B. Veazie, Dr. E. W. Gudger and Dr. William King Gregory. The portions concerning batrachians and reptiles have been verified by Dr. G. Kingsley Noble.

Shortly after Professor Cope's death, Persifor Frazer published a brief bibliography and biography. At the memorial meeting of the American Philosophical Society on November 12, 1897, a biographic symposium was held at which Theodore Gill reviewed Cope's work among the reptiles and fishes, while his contributions to geology and mammalogy were discussed by William Berryman Scott and myself. Appreciative, independent biographies were also written by Hosea Ballou, Marcus Benjamin, J. S. Kingsley and Persifor Frazer, by myself, and Miss Helen Dean King. The prolonged and intensive research into the extremely full life and works of Cope, in which I was first aided by Mrs. Hermann O. Mosenthal, dates back to 1897. This research was suspended for several years and then renewed with still deeper and more extensive research by Miss Helen Warren in the year 1928, continuing up to the present time.

Professor Cope's family has been warmly sympathetic in this great undertaking and has generously donated to the Osborn Library of the American Museum, the entire family and scientific correspondence of Professor Cope, beginning with the diaries of his boyhood. Some members of Professor Cope's family at the instance of his daughter, Mrs. Julia Cope Collins, have generously contributed a sum to aid in this research, which has been partly sustained also by the Osborn Research and Publication fund of the American Museum of Natural History.

Thus step by step all the materials have been brought together and are now assembled in condensed form for the present Biographical Memoir of the National Academy of Sciences, prepared with the able aid of Mrs. Helen Warren Brown. It is expected that this relatively brief and concise biography of fourteen thousand words will be followed by a volume giving a more comprehensive account of the life and works of this man of remarkable genius.

The bibliography of Cope will be of incalculable value to all workers in vertebrate zoology and palaeontology, as well as in biology and philosophy, because it points out all the available sources, of both permanent and very fugitive character, in which may be found the outpourings of his lifelong observations and the brilliant series of generalizations which flowed from his creative mind.

HENRY FAIRFIELD OSBORN.

# EDWARD DRINKER COPE

### BY HENRY FAIRFIELD OSBORN

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## INTRODUCTION

Edward Drinker Cope was born in Philadelphia, the cradle of American philosophic and scientific thought, on July 28, 1840, grew up a contemporary of the palaeontology which Georges Cuvier had founded in 1799, and spent his life and a considerable fortune in its furtherance. Happening to be born with an observing and enquiring mind, he absorbed in childhood the stores of natural history painstakingly gathered by pioneer scientists of the sixteenth, seventeenth and eighteenth centuries, worked them over with genius, adding as he grew older a first hand acquaintance with the unbelievably ancient fossils discovered by fur-traders in the plains of Nebraska, Montana, Wyoming, Colorado, Kansas, New Mexico, Oregon and Texas, and proceeded to astonish his conservative predecessors by setting forth overwhelming evidence of the theory of evolution as traced from fossil through living forms, from the lowest single-celled organism to man.

Altogether he contributed more than 1,300 papers to scientific literature, making known more than 600 species and many genera of extinct vertebrates new to science, many of which he had personally discovered in the Cretaceous strata of Kansas or the Tertiary of Wyoming and Colorado. Among these were some of the oldest known mammalia, obtained in New Mexico where he had served with the United States Geological Survey under G. M. Wheeler in 1874. In 1885 Cope wrote with some satisfaction that he had traced successfully the primitive ancestry of the reptiles, birds and fish, back to their point of origin and that among the mammalia he had done the same thing for the deer, the camels, the musk, the horse, the tapir, the rhinoceros, the cats and dogs, lemurs and monkeys, and had important evidence of the origin of man among the mammals.[1] The marsupials he had traced only in part and was also still baffled by the exact tree of the bears, elephants, hyenas and hogs.

## ANCESTRY AND BOYHOOD

The Copes of Philadelphia were Quakers, and like many members of the Pennsylvania Society of Friends, very prosperous. They were a branch of an old and distinguished Wiltshire family, one member of which, Oliver, having fallen upon hard times, bought some land from William Penn in 1687 and moved his family to America. They prospered and Oliver's great-grandson, Thomas Pim Cope, became in 1821 proprietor of the Cope line of packets running between Philadelphia and Liverpool. Alfred Cope, son of Thomas, was therefore able to live a more or less retired life in the family place "Fairfield" not far from Philadelphia and to indulge his love for cultivating fine trees, rare shrubs and flowers.

At Fairfield his son, Edward, was born in July 1840 and grew up under his father's tutelage. His early education although ostensibly aimed to make of him either a farmer or a ship-owner, when taken into relation with his strong natural bent, moulded him firmly into a man of science. He was taught the names, characteristics and proper care of the trees and plants under cultivation in his father's eight-acre farm. He was encouraged to observe the habits of the farmyard beasts and to keep pets. He was trained to make accurate maps, beginning with a diagram of the farm and branching out to the several states, the whole United States, the continent of North America, and finally the world. He learned a primary division of animals from his father:

Pigs have bristles,
Cows have hair,
Birds have feathers,
Snakes are bare.

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[1] *Origin of Man and Other Vertebrates, Professor* Edward D. Cope, Popular Science Monthly, September, 1885.

He was also permitted, as he grew older, to use his father's library which included such natural history texts as Mark Catesby on the *Natural History of Carolina, Florida and the Bahamu Islands.*

When he was six years old Edward was taken to a museum in Philadelphia, either Barnum's or the one in the Academy of Natural Sciences building. There he saw the Mastodon skeleton and Koch's disproportionate *Hydrarchus* (Zeuglodon), the water king, which had been constructed from the remains of three skeletons to the astonishing length of 114 feet. Stuffed monkeys, alligators and crocodiles were also on display and Edward wrote a full description of the trip to his grandmother, stating characteristically: "Does thee know what that is? I will tell thee." The following year the boy was taken to Boston on one of his grandfather's ships and wrote a little journal along the way, sketching in it starfish, dolphins and flying fish, as well as the Bunker Hill monument. A year or two later he was taken to Cuba and was evidently deeply impressed by the tropical scenery; when he was seventeen he wrote from memory a very vivid description of a ride along a southern beach, skirting a most convincing jungle and palm trees. When he was about nine years old he was sent to school in Philadelphia and his visits to the Academy Museum became frequent. He went alone or with school-fellows and kept careful account of what he had seen, often illustrating by sketches of the animals his attempts at classification by name and characteristics. At thirteen, in 1853, he was sent to the Friends Select School at Westtown, Pennsylvania, where his lessons were usually well reported but the conduct of his restless and mischievious spirit often fell below par; this in spite of many remorseful promises of reform.

The Westtown School library seems to have been well-stocked; there in February 1856 Cope, at the age of fifteen, read Darwin's *Voyage of a Naturalist* [2] and pronounced it too full of geology. The course of school study, however, was the routine reading, mathematics, Bible study, penmanship, Greek and Latin with a little chemistry thrown in. In the summer the young naturalist made strides ahead in his favorite studies; not being very robust he was sent by his father to work on farms of various relations. These farms differed from year to year; the first was a garden truck farm, the next devoted to wheat and corn and another to fruit raising. By his own account the lad employed his spare time in studying "nurserying, ornithology, herpetology, botany and flageoletology." He explored meadows, woods and fields, collecting birds, snakes, insects, reptiles, fish and flowers, for later comparison in the Philadelphia museum. He became more and more embued with the beauty in Nature, of which he had a strong sense, more and more eager to unravel the plan and meaning of life, both physical and mental, and more and more determined not to become a farmer.

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[2] *Voyage of a Naturalist,* Charles Darwin, Harper Brothers, 1845. 2 vol.

## YOUTH

He was persistent in this latter determination and advanced so many arguments against the economic wastefulness of the contemporary methods of farming that, when he was nineteen, his father finally gave in and set him to studying French and German under a private tutor. Dr. Joseph Thomas, the scholar selected, was an excellent linguist and developed in his pupil a fluency and familiarity with languages which was of great value to him. Cope consented to the language courses with the express understanding that they would "enable me to read useful books of a literary or scientific character."

His first formal contribution to scientific literature came during this same year of 1859 with his communication of a paper on the *Salamandridae*[3] to the Academy of Natural Sciences at Philadelphia, in whose halls he had been an interested student since his sixth year.

The ambitious youth soon convinced his father of the necessity of his studying comparative anatomy at the University of

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[3] On the *Primary Divisions of the Salamandridae*, with Descriptions of Two New Species. *Proceedings of the Academy of Natural Sciences of Philadelphia* (Vol. XI), 1859, pp. 122-128.

Philadelphia under Dr. Joseph Leidy as it would give him a proper knowledge of how to treat stock, should the occasion arise. He further remarked that he was already, at the age of twenty, familiar with the main points of anatomical structure and could perfect himself in the minutiae in a winter.

### Young Manhood

Having completed the course with Leidy in the early Spring of 1861, he spent some months in cataloguing the reptilian collection of the Academy of Natural Sciences and then proceeded to Washington to study the herpetological collections of the Smithsonian Institution under Professor Spencer F. Baird. The winters of 1861-2 and 1862-3 were passed thus in war-torn Washington, while the summers were spent in farm work and in scientific writing. Most of the papers of these years were on herpetology, but one ventured into ichthyology and one into mammalogy. At the age of twenty-two, in the Spring of 1863, Cope went abroad to study the collections at Berlin, Leyden, Munich, Vienna, Paris and London. He remained abroad a year and returned in 1864 to an appointment as professor of natural science in Haverford College, a post he held for three years and then gave up in favor of scientific exploration and writing.

### Manhood

Cope was married in July 1865 by the Quaker ceremony to his distant cousin, Annie Pim. Their only child, Julia, was born in July of the following year. In March 1867 Cope visited Agassiz at Cambridge and examined the great Brazilian collections. Three months later his own life as an explorer of remote and hazardous fields began with the apparently mild proposal of taking his wife and baby to the Virginia Springs for a vacation.

There, in Montgomery County, he explored the cave fauna—a type of investigation in which he was again engaged shortly before his death, thirty years later. In October 1867 he progressed to Maryland, examining the Eocene and Miocene beds which lie between the Potomac and Patuxent rivers. The next

March he turned his attention to the New Jersey marly sands near Pemberton in Burlington County. These he explored with his new found friend, Professor Othniel Charles Marsh of Yale, who was to become one of his bitterest rivals. But in 1868 they explored the marl peaceably together and found three new saurians of apparently known genera, though Cope was not certain of this classification and ascribed them tentatively to *Mosasaurus, Glavialus* and *Brimosaurus*. The summer of 1869 found him among the mountains of McDowell County, North Carolina, hunting insects, salamanders, and fish and investigating the caves of the Black range, Craggy, Blue Ridge and Great Smoky mountains. Later in the season he lived near Raleigh inspecting the Miocene marl which exists thereabouts. In 1871 Cope's private explorations, which had thus far been financed from his own slender allowance, took him to the Kansas Cretaceous, but his field trips thereafter were in part financed by the national or State Geological Surveys with whom he had first become affiliated in 1865.

## WORK WITH GEOLOGICAL SURVEYS

Cope was busy with Herpetology in 1865, when Dr. Worthen of the Illinois State Geological Survey sent him the remains of a carboniferous salamanderlike amphibian for description. He named the creature *Amphibamus grandiceps* and transferred his enthusiasm for hunting living reptiles into seeking out the fossil forms. Extinct and living forms he considered together and light was shed from one to the other. In 1870 he gave expression to the results of his studies in a well-illustrated *Synopsis of the Extinct Batrachia, Reptilia and Aves of North America,* a brief diagnosis of groups with descriptions of new genera and species from the coal measures of Linton, Ohio. This was supplemented in 1875 by a *Synopsis of the Extinct Batrachia from the Coal Measures,* which appeared as part of the annual report of the Ohio Survey.

In 1872 his friend F. V. Hayden offered him a post with the U. S. Geological Survey and Cope went to Wyoming to examine the Bridger and Bitter Creek regions with a driving activity which exhausted him and ended in his first serious illness. The trip began like so many of Cope's with three days and three nights in a stage coach, bumping and jerking into the Wyoming wilderness, and consisted in weeks on horseback in an arid land amid constant danger of Indians, who were decidedly upon the warpath, but who fortunately considered Hayden mad and consequently an object of especial divine protection. The following summer Cope worked in the Colorado Miocene, again with Hayden and in 1875 his *Vertebrata of the Cretaceous Formations of the West* was published by the Government Printing Office. Cope's work with Hayden, however, culminated in the publication in 1884 of a volume, popularly known as Cope's Bible: *The Vertebrata of the Tertiary Formations of the West.*[4] Book One of this work comprised the first half of Cope's final report to the Hayden Survey. It includes the Eocene faunas and a part of the Oligocene (Lower Miocene) Rodentia, Insectivora, etc., Carnivora. The second book, to include the Oligocene (Lower Miocene) Ungulata and the Miocene ("Loup Fork") fauna was never published although a large number of the plates prepared under Cope's direction by William Diller Matthew were published in 1915 by the American Museum of Natural History with the co-operation of the U. S. Geological Survey.[5] The failure to get this volume published was one of the great disappointments of Cope's life. When it became apparent that the original Congressional appropriation for the publication would not be available, he spent many weary weeks and months in Washington from 1886 until 1890, trying to get a special item covering the costs passed as part of the Sundry Civil Bill. He waited upon Congressmen, Senators and Secretaries of the Interior, interviewed, prepared briefs, pleaded, and waited. Several times the item was approved by the Senate, but failed in the House. Finally Cope was referred back to Major Powell and the volume eventually appeared in the much abridged form of 1915.

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[4] Report U. S. Geol. Survey of the Territories, (Hayden), Vol. III, pp. i-xxxv, 1-1009, Pls. I-LXXVa.

[5] Hitherto Unpublished Plates of Tertiary *Mammalia* and Permian *Vertebrata* (With W. D. Matthew). *Amer. Mus. Nat. Hist. Monograph Series No. 2.*

Cope served as palaeontologist with the U. S. Geological Survey of the territory west of the 100th Meridian under G. M. Wheeler in 1874 and 1875, working in New Mexico, Montana and Oregon, and eventually publishing his report with that of Wheeler in 1877.[6] The summer of that year [1877] Cope worked with the Wheeler Survey in the Permian of Texas, the results of his investigations being published in several bulletins of the Survey.

Besides his connection with the U. S. Geological Survey, which terminated when Marsh was placed in command, Cope worked with the Indiana State Survey, with the Canadian Geological Survey, and with the Texas State Survey. In the Indiana work he collaborated with Wortman publishing an *Account of the Mammalian Fauna of the Post Pliocene Deposits in the State of Indiana* in 1884 as part of the fourteenth annual report of the State Survey. His studies took him to Canada in the eighties and he became connected with the Canadian Geological Survey with the resultant publication of his *Vertebrata of the Swift Current Creek Region of the Cypress Hills* in that body's annual report of 1885, and of his *Vertebrata from the Tertiary and Cretaceous Rocks of the Northwest Territory* in the Contributions to Canadian Palaeontology, of 1891. The following year he returned to Texas, serving with the State Survey. The chief publication resultant was *A Preliminary Report on the Vertebrate Palaeontology of the Llano Estacado* which appeared in 1893, occupying ninety pages of the fourth annual report of the Survey.

## TWENTY YEARS OF INTENSIVE RESEARCH

The years after his retirement from the faculty of Haverford College were not solely devoted to work for the various Geological Surveys mentioned above. From late autumn until early Spring of these years Cope lived in Philadelphia, studying and describing the fossils collected on summer journeys and those sent him by other collectors in the same fields, writing long monographs and short papers, correcting and revising endless proofs, lecturing before the Franklin Institute and the Academy of Natural Sciences, and after 1878 publishing the *American Naturalist* as well. During these winters he occupied no professorial chair, though in 1873 he was considered by Princeton College for the Chair of Natural History. He was not enthusiastic about this position, however, because it would cut into his hours for research, and President McCosh of Princeton, on the other hand, was unenthusiastic about Cope, or so Cope thought, because of his advanced views regarding evolution. Occasional summers of these twenty years of research were spent away from the collecting fields. During the summer months of 1875 Cope remained in Philadelphia in charge of the division of organic material in the permanent exhibit of the Educational department at the Centennial Exposition; geological and palaeontological specimens of the United States were assembled under his direction and in later years he frequently referred to the Exposition with great pride. In 1878 he went abroad to attend the Dublin meeting of the British Association for the Advancement of Science, to renew his familiarity with the fossil collections at London, Paris and Rheims, and to make the acquaintance of palaeontologists and geologists to whom he was already known through his writings. Among these men in the order of Cope's personal preference were, Professors W. Boyd Dawkins, Leith Adams, Macalister (of Dublin), Traquair (of Edinburgh), and Thomas Huxley—all palaeontologists of the Vertebrata—and among geologists, Professor John Evans, Mr. Hicks of Wales and Mr. Pengelly of Cornwall.

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[6] Report upon the Extinct Vertebrata obtained in New Mexico by Parties of the Expedition of 1874. *Report of the U. S. Geogr. Surveys west of the 100th Meridian (Wheeler) IV. pt.* II. pp. 1-370.

Returning to his field work, Cope visited California and Oregon in 1879 making the friendship of Professor Condon of Oregon, with whom he had long discussions of his present work in the Silver Lake district, of the fossils he had found and discovered in the past, and of those he hoped to find in the future. 1881 took him back to the Santa Fe trail and New Mexico, this time working alone, while in 1882 he returned to Oregon. During the next three summers his eagerness to increase his funds, for the purchase and collecting of material for his precious monographs, led Cope into disaster. He had inherited more than a quarter of a million dollars after his father's death in 1875 and with almost childlike faith he invested his capital in silver mines in Mexico. He personally investigated the mines and detected silver, but failed to detect the schemes of promoters. Seeing his misplaced trust too late he feverishly threw good money to cover bad. Finally in 1886 he realized that he was in very straightened circumstances; he struggled with poverty for the rest of his life.

Honors came to Cope during his years of intensive research. In 1872 he was made a member of the U. S. National Academy of Sciences and in 1878 of the Societie Geologique de France. The Bigsby gold medal of the Geological Society of London was awarded to him the following year. In 1886 he was elected a member of the Imperial Society of Moscow and received the honorary degree of Doctor of Philosophy from the University of Heidelberg. This was his only academic degree. In 1891 the results of his research were recognized by the award of the Hayden Memorial medal. Distinction had also come to him through his connection with the Academy of Natural Sciences, the American Philosophical Society and the *American Naturalist,* of which he was editor and publisher.

## CONNECTION WITH THE ACADEMY OF NATURAL SCIENCES AND THE AMERICAN PHILOSOPHICAL SOCIETY

Cope's connection with the Academy of Natural Sciences at Philadelphia began with his first visit to its halls, when he was six years old. The publication of his first paper in the Academy Proceedings of 1859 strengthened the bond his constant childhood visits had made and upon coming of age in 1861 he became a member of the Academy, whose herpetological collections had already afforded him his first scientific job. For twenty years thereafter Cope's shorter papers, with the exception of those appearing in the *American Naturalist,* were usually published by the Academy.

He served it as Curator from 1865 until 1873, as Corresponding Secretary from 1863 until 1876 and as a member of the Council in 1879, but he was not satisfied with it and his outspoken criticism of the management of its affairs, which he believed placed buildings before publications and wealth before accomplishment, made him many enemies. He suggested three fundamental changes in its organization without avail: first that a series of fellowships open only to experts of established reputation be inaugurated; second, that the officers of the Academy should be selected from the fellows only; third, that the Professors should be, *ex officio,* members of the Council. This attempt to keep science for the scientists, as far as the actual machinery was concerned, was frowned upon and defeated.

Finally in 1883 Cope resigned from the Academy and in 1885 described himself as elected to "a position of honor if not emolument in the American Philosophical Society." For years those papers not published by the U. S. Geological Survey, the *American Naturalist* and the *Open Court* or the National Academy of Sciences were included in the proceedings of the American Philosophical Society. Yet in making his will Cope forgot the Philosophical Society and remembered the Academy.

## EDITOR OF THE AMERICAN NATURALIST

*The American Naturalist* of Salem, Massachusetts, was for sale in 1878; Cope bought a part interest. He moved the magazine to Philadelphia and arranged to edit it jointly with Professor A. S. Packard. In 1887 he became editor-in-chief and so continued until his death, but although it provided him with an organ for disseminating his opinions on science, sociology, religion and government and thus increased his prestige and influence, the *Naturalist* was a constant drain upon his purse and upon his energy, as its publishers were numerous, difficult to manage and expensive.

Cope's two most important contributions to the literature of Evolution were issued independently of the *Naturalist,* the

*Origin of the Fittest* being brought out by Appleton in 1886 and *Primary Factors of Organic Evolution* by the Open Court Publishing Company in 1896.

## LATER YEARS

It being apparent in 1886 that Cope had been swindled out of his patrimony and that something must be done to meet even the modest expenses of his family, he leased his Philadelphia dwelling and moved into the adjoining house which he had previously used as a workroom and storehouse. He merely pitched camp among the bones and manuscripts and set up house-keeping. He began negotiations for the sale of his North American fossil collection and endeavored to secure an appointment as Assistant Secretary of the Smithsonian Institution, but failed. He was, therefore, doubly glad to receive the professorship of geology and mineralogy at the University of Pennsylvania in 1889 and to occupy that position until 1895, when he was transferred to the professorship of zoology and comparative anatomy previously held by Dr. Joseph Leidy.

He went joyously to his work with the Texas Survey in 1892 and 1893, investigating both that state and North Dakota. These were his last Western trips; the remaining three summers of his life were varied only by short trips to eastern caves, such as the Port Kennedy caves in Pennsylvania and the Megalonyx caves in Ohio and Kentucky. The sale of his North American fossil mammalian collection was concluded in 1895 to the American Museum of Natural History, which also later secured the Pampean collection he had bought from Buenos Ayrian scientists in Paris in 1878. Cope hated to part with his North American mammalian more than any other feature of his poverty, but he remained gay and cheerful despite his disappointment and despite the fact that he was beginning to be threateningly ill. In 1896 he was elected to the presidency of the American Association for the Advancement of Science and would have delivered the presidential address in August 1897 had his long-menaced health held out. He fell ill in the spring of 1897 and continued doggedly to attend his classes at the

University, but in April he became really very ill and on the twelfth of that month he died. Shortly before his death he delivered in delirium a brilliant and unified lecture on the *Felidae* and his last conscious sight was of giant bones, piled on every side of his cot. The Quakers, from whose Society Cope had resigned in 1878, came to bury him and to help execute his will, dated October 1, 1895, the principal provisions of which were as follows:

> I hereby appoint Jno. B. Garrett of Philadelphia and Henry F. Osborn of New York to be the Executors of this Will. In case of the death of either party, I appoint as substitutes Asa S. Wing of Philadelphia and William B. Scott of Princeton, N. J., the former in place of J. B. Garrett, and the latter in place of H. F. Osborn.
>
> . . . Of my scientific books I direct that all which they desire shall be taken by the Biological School of the University of Pennsylvania for their library, and the remainder shall be sold and the proceeds divided equally between my wife and daughter.
>
> Of my collections, I direct that all those preserved as wet preparations shall be given to the Academy of Natural Sciences for their museum.
>
> I leave my osteological collections to the School of Biology of the University of Pennsylvania for the use of original investigators primarily, and for use by students when said specimens are not in use by original investigators.
>
> My collection of minerals I present to the University of Pennsylvania to be placed in their general collection. My collection of skins of animals together with the skeleton which accompanies each skin, if any there be, I present to the Academy of Natural Sciences of Philadelphia.
>
> My collection of Fresh water Mollusca I present to the School of Biology of the University of Pennsylvania; the first set of duplicates to go to the Cincinnati Society of Natural History, and the second to the American Museum of Natural History of New York.
>
> My palaeontological collections I divide into three parts. *First,* the North American Collection; *Second,* the South American, i. e., the Pampean Collection which I purchased of the Buenos Ayrian Exhibitors at the Paris Exposition of 1878, and small collections from the West Indies and Mexico; *Third,* European Collections, chiefly from the Miocene of Allier, France. I direct all these to be sold for the benefit of my estate. I advise my executors that these collections have cost me about $50,000.00. I place no restrictions on them as to the manner of sale except that it may be done as soon as the best advantage indicates.
>
> Of the proceeds of all sales hitherto mentioned in this will, I direct

that my debts shall be paid. . . . The remainder, which I suppose will amount to about $40,000, I leave to the Academy of Natural Sciences of Philadelphia as an endowment for a professorship or curatorship of Vertebrate palaeontology under the following conditions: Said professor shall be an original investigator of merit who shall be elected by the Council of the Academy and shall have the approval of the U. S. National Academy of Sciences, as an original investigator of merit. His position and services shall be those of a professor as defined in the present by-laws of the Academy: i. e., he shall have entire charge of the material embraced in his department, and the curators shall not interfere with his jurisdiction excepting to see that he does not neglect his duties. Of the income of this sum, $400 per annum shall be used for the procurement of vertebrate fossils either by collection or by purchase.

The remainder of my real and personal estate I leave to my wife during her lifetime; and after her death to my daughter, Mrs. Julia C. Collins. In case both die, I leave said remainder, one half to my son-in-law, W. C. Collins, and the other half to augment the purchase fund of the chair of vertebrate palaeontology in the Academy of Natural Sciences.

Codicil. March 24th, 1896.

I direct that after my funeral my body shall be presented to the Anthropometric Society and that an autopsy shall be performed on it. My brain shall be preserved in their collection of brains, and my skeleton shall be prepared and preserved in their collections, in a locked case or drawer, and shall not be placed on exhibition, but shall be open to the inspection of students of anthropology. The remainder of my body, I direct, shall be burned and my ashes be preserved in the same place as shall contain the ashes of my esteemed friends, Dr. Jos. Leidy and Dr. Jno. A. Ryder.

## CONTRIBUTIONS TO GEOLOGY AND STRATIGRAPHY

Inextricably involved in Cope's chosen task of unravelling the problems of life, the structure, functions, development and phylogenetic descent of animals, as well as the broad metaphysical questions which underlie and condition all these problems, were his investigations of geology. These were in his eyes subordinate to palaeontology, but necessary to its proper chronology, consequently he had very little to say concerning structural or dynamic problems of geology and regarded every question in that field from the strictly historical view. Stratigraphy, the determination of limits, distribution, succession and geological date of the formations in which his fossils were embedded, as well as the correlation of these formations with their equivalents in other parts of the world, constituted his geological occupations; for he could make out the phylogenies of the various animal groups only after he had determined the true chronological order of succession of the genera composing the phyletic series.

When Cope began his studies in the Cretaceous of Kansas in 1871, the whole region was comparatively new and for the most part geologically unexplored; he was, therefore, forced to work out the stratigraphical succession for himself. This was most fortunate, since it made him personally familiar with the strata in which the fossils lay, a rare opportunity for scientists of that day, among them, Leidy, who had worked all his life from bones picked up by chance passersby from the surface of the ground where they had been weathered out of the matrix. Sternberg's method of getting out skeletons and shipping them so far as possible *in situ* had not yet been perfected, so Cope came to geology through palaeontology. Accordingly most of his writings on the subject are scattered through his palaeontological papers and would be very difficult to reassemble, but in the opinion of Professor William Berryman Scott, from whose material this article is prepared, those scattered observations of Cope's were epoch making.

They came, says Professor Scott, at a time when "the haziest ideas were entertained regarding the position and succession of most of the numerous and extensive fresh-water formations, which characterize the western part of the country. It would be an exaggerated claim to say that he had brought order out of the chaos, but it is hardly too much to say that he, more than any other single individual, contributed to this great result. Such was his power of insight that he was occasionally too far ahead of his contemporaries, and only of late have certain of his views received their just meed of appreciation. In some instances, indeed, we are coming back to the opinions which he first promulgated, but which were ignored or rejected at the time.

"Great as his genius undoubtedly was, Cope was not, even as an investigator perfect and free from every fault; to use a Gallicism, he had 'the defects of his qualities.' He was so impressed with the immensity of the work to be done, with the necessity of speed, and with the shortness of the time allotted to him, and he was often so carried away by the rushing impetuosity of his thought, that he published no little hasty and ill-considered work. He frequently made blunders that a little more care and consideration would have enabled him to avoid, so eager was he to say what he had to say, and then pass on to the attack of some new problem. To balance this defect, however, he had no tendency to pose as infallible, or to defend errors simply because he had himself committed them. While extremely clear as to his own opinions and the grounds upon which he held them, and while ready to give and take hard knocks in the defense of his views, he was always ready, on good reason being shown, to change those views, and he allowed no weak regard for fancied consistency to hamper the freedom of his thought. . . . Those who are familiar with the vast and desolate regions where the work was done, and who know the great difficulties which the pioneer explorer has to overcome, will view the matter in a very different light and will always regard with admiration the rapidity, clear-sightedness, and skill with which the great complex of fresh-water deposits was marshaled in orderly array, their succession determined, and their equivalences with similar deposits in other parts of the world made out."

This correlation of the various fossiliferous horizons of North America with those of Europe, made possible by Cope's wide and accurate knowledge of the successive vertebrate fauna of both continents, was one of his most valuable contributions to geology. Of this Professor Scott wrote in 1897:

"Of late it has become rather the fashion to deprecate as premature all attempts at correlating American and European formations and even to deny the possibility of making such correlations in any trustworthy way. From the strictly geological point of view, such a conservative attitude is natural enough; but Cope did not regard the question from a purely geological standpoint. He was, above all things, a zoologist, and his principal life work lay in tracing the origins, phylogenies, and relationships of animals, their migrations and geographical distribution, and he clearly saw that such determinations could not be successfully undertaken unless the order of successive appearance of the various animal types in the different continents could first be established. To this end, geological correlations of widely separated deposits are an indispensable necessity, and a false correlation is better as a working hypothesis than none at all, for it sets up a definite thesis in place of vague surmises.

"In several of these determinations of the equivalences between the fresh-water Tertiaries of North America and those of other continents, Cope was a pioneer, and while not all of his correlations have stood the test of fuller knowledge, many of them have only grown stronger with the advance of time and stand out as guide-posts in the further prosecution of the work. For example, his correlations of the Wasatch with the Suessonian of France (in which he followed Marsh), and of the White River with the Oligocene of Ronzon, have been abundantly confirmed by discoveries undreamed of when the equivalences were first suggested. The value of these determinations to the morphological palaeontologist can hardly be overestimated, and every investigator owes a debt of gratitude to Cope for his labors in this department of geology."

A cursory survey of Cope's work in geology, taken in the order of geological chronology, begins with his single interest in the Permian rocks among the Palaeozoic formations. A controversy about the existence of Permian rocks in the United States had been going on since 1852, when Marcou had reported their presence in Texas and Swallow, Meek and Hayden had confirmed this discovery by finding them in Kansas as well, in 1858. Other authorities disputed this determination and maintained that there was no well-defined Permian rocks in the United States. In 1877 Cope obtained his first specimens of Amphibia and Reptilia from Texas and proceeded to publish a series of descriptions of extinct vertebrata from the Permian and Triassic Formations of the United States, in which he fully determined the Permian character of rocks in both Texas and Illinois. The researches of I. C. White and Fontaine upon the plants and of C. A. White upon the invertebrates later confirmed Cope's conclusions.

This identification of horizons in regions where they had not previously been known continued in Cope's work in the Triassic, Jurassic and older Cretaceous. Though he neither discovered new formations, nor corrected the reference of those mistakenly placed in the geological columns, he did investigate very thoroughly, especially in the Cretaceous. He was the first to discover Dinosaurian remains in the Laramie stage, and is said to have been the first to recommend the reference of that horizon to the Cretaceous, a radical innovation which was finally adopted by his contemporaries, as it proved its value in giving a fixed point in the obscure formations intervening between the Cretaceous and Tertiary.

In the unravelling of the fresh-water Tertiaries which cover such vast areas of the West lay Cope's most signal service to geology. It is difficult to exaggerate the value of these services according to Professor Scott, who has summed them up, as follows:

"First of all should be mentioned his discovery and identification of the Puerco, or oldest Eocene, which may fairly be called 'epoch-making.' Not only was a very extensive, entirely new and highly significant fauna brought to light, but also the existence of a long time-interval between the Laramie and the Wasatch was demonstrated, showing that the supposed continuity of sedimentation connecting those horizons was illusory. This discovery necessitated an entire change in the views concerning the geological history of the Western region in post-Cretaceous times. The Puerco carried the Eocene much farther back than had been expected, and opened up a new world to the palaeontologist.

"The succeeding Wasatch formation had been discovered and named by Hayden, and its correlation with the Suessonian of Europe had been pointed out by Marsh, but it is to Cope that we owe much the greater part of our knowledge concerning its distribution, its relations, and its place in the geological column. Personally, or through his collectors, he thoroughly explored the Wasatch of New Mexico and Wyoming, elucidating its fauna with wonderful skill and insight, and strengthening the theory of its close correspondence to the Suessonian of France, with which his studies in that country had made him familiar.

"In the Bridger formation, Cope added very largely to what was known regarding the vertebrate fauna, and established the position of the Wind River beds as forming a substage at the base of the Bridger and making a transition from the older Wasatch to the Bridger proper. He also made a classical series of investigations upon the fishes of the Green River shales, and pointed out the probable equivalence in time of these beds with those of the Wind River substage. He first described the fauna of the Manti beds of Utah of approximately contemporaneous age."

Hayden and Leidy had very thoroughly examined the White River formation and its very rich vertebrate fauna, and Leidy in his famous monographs had determined these beds as being of Miocene age. Cope challenged this determination and referred the formations rather to Oligocene, stressing the importance of their correspondence with European formations, but the followers of Leidy remained firm adherents of the Miocene determination and considerable confusion resulted. The misleading Miocene determination remained in use for some time, despite Cope's detection of White River beds in North Dakota two hundred miles north of the first discovery and his extension of the range of that formation into the Swift Current region of the Northwestern territory of Canada. Fossils sent him by the Canadian Survey facilitated this latter determination and showed him certain resemblances to the contemporary life of Europe in addition to those which he had detected in the United States.

The Amyzon shales of Nevada and central Oregon and the

Florissant beds of Colorado came under Cope's examination during his preparation of a description of a series of fishes which had been obtained from these formations. He was inclined to consider them of Oligocene or late Eocene age, although somewhat in doubt as to their exact geological date, because of the absence of decisive stratigraphical indication and because fossils common to them and other localities were lacking. In dealing voluminously with the abundant vertebrate fauna of the John Day stage, Cope had little to say regarding its geology beyond that which had been said by his predecessors. In the Loup Fork, however, his observations were original and contrary to precedent.

Leidy had first described the Loup Fork fauna from fossils sent him by explorers and fur traders, who had picked up bones lying on the surface of the ground. These had been weathered out from overlying Pleistocene deposits and were intermixed with too many extinct and peculiar genera to altogether retain their modern classification. Leidy accordingly determined this admixture of fauna as Pliocene, but Cope was suspicious of this reference from the first. When his opportunity of personally examining the Loup Fork beds presented itself, he sought out areas where the strata were at the surface and where no newer overlying formations could falsify his collections. He thus accurately determined the actual elements of the Loup Fork fauna and found them lacking the Pleistocene forms which former casual collections had mistakenly included in them. He came at once to the belief that the Loup Fork beds were not Pliocene at all, but Upper Miocene and extended their area to New Mexico, Texas and the valley of old Mexico. Though considered a great reform in Western stratigraphy by many American geologists this determination was not universally adopted, and while some authorities continued to uphold Leidy's reference confusion prevailed, much to the embarrassment of European writers.

Having determined the fauna as Upper Miocene, Cope proceeded to show that the formation is divisible into two distinct substages. Grinnel and Dana had discovered certain lacustrine deposits in the valley of the Smith River in central Montana in 1875 and determined them as Pliocene, by which they supposedly meant Loup Fork. Cope sent a collector into this region and from the material gathered showed that these beds which Cope assigned to Nebraska and South Dakota as well as Montana, constituted a substage of the Loup Fork and were older than any part of that formation which had been known up to that time. This determination was of significance in helping to bridge the gap between the John Day and the typical Loup Fork and eventually proved to be of great value in making correlations with the fresh-water deposits of the European Upper Miocene.

The Pliocene of the interior portion of the United States was at this time very vaguely known, but during his studies of the fishes Cope identified certain beds in Idaho and Central Oregon as Pliocene and proposed the name Idaho beds for them. He also was the first to make known the Blanco beds of Texas, describing their stratigraphy, geographical distribution and fossil contents, and thus disclosed one of the most typical and unmistakable of North American fresh-water Pliocenes.

In the Pleistocene, Cope's work consisted in the determination of the successive mammalian faunas and the consequent foundation of the divisions of the North American Pleistocene. This work was thoroughly done in the Sheridan or Equus beds of the West and Southwest in widely separated localities, and in the caverns of the East. Notable among these caverns were his early and later investigations of the extensive assemblage of Pleistocene vertebrates in the Port Kennedy bone cave of Pennsylvania, which formed the subject of one of his last publications. The Sheridan beds and the Megalonyx beds of the East, he at first considered Pliocene, but eventually changed his opinion and classed them with the Port Kennedy faunas as Pleistocene.

Investigations of the geology and palaeontology of the Atlantic coast, though they formed Cope's first introduction to palaeontology, yielded up such fragmentary and unsatisfactory material that the results of his labors are less apparent and he remains the geologist, palaeontologist and evolutionist of the Western plains.

## CONTRIBUTIONS TO HERPETOLOGY[7]

Cope was a naturalist, not a specialist in one branch of natural history. Herpetology, however, was the first field to interest him and remained one of his chief studies, so that his work in this line ranks with the specialization of many men. The first exhibit of the Museum of the Academy of Natural Sciences at Philadelphia of which the six-year-old boy wrote to his grandmother was the mammal *Hydrarchus* (Zeuglodon) then falsely labelled the whale-like lizard. Visiting the Museum a year or so later, he noted in his little journal: "Some saurians which are fossil skeletons that are found in the rocks of England, but it is very curious that they are monstrous sea lizards." In the woods and fields at Fairfield, in the school grounds at Westtown and during summers on the Pennsylvania farms of various cousins, he sought salamanders, snakes and tortoises under roots, stones, fallen trees and layers of leaves and identified his trophies with those described in his father's library or preserved in the Academy Museum.

Just before his fifteenth birthday he wrote to his father, "I caught a large water snake or water wampum, as they are called here—one of the Colubers—in Brandywine and brought it home. It was about as long as my leg, but very thick for its length, . . . I afterwards found it had eaten a large bull frog . . . I soon convinced myself it was not (poisonous) by examining its mouth which wanted fangs, and as all non-venomous have, it had four rows of teeth in its upper, and two in its lower jaw, and two rows of scales under its tail." Throughout his life he collected snakes, toads and salamanders whenever he found a strange species, shipping them home, some alive and some in alcohol, from the muddy streets of San Antonio, the deserts of New Mexico and the mountains of Nevada and North Carolina. When Cope was nineteen, in 1859, his first formal contribution to scientific literature appeared in the April Proceedings of the Academy of Natural Sciences under title, *On the Primary Divisions of the Salamandridae, with descriptions of Two New Species.* Therein the youthful scientist instituted modifications of the systems previously adopted in the United States.

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[7] See Theodore Gill, Retiring Presidential Address before the American Association for the Advancement of Science, 1897; also *Proceedings of the American Philosophical Society*, November 12, 1897.

While still too young to become a member of the Academy, which he joined in 1861 upon coming of age, he occupied several winter months in cataloguing the serpents contained in its Museum and introduced innovations in the systems of classification then in use. He next studied the herpetological collections of the Smithsonian Institution under Spencer F. Baird and then went abroad for his intensive study of the collections of England, France, Austria, Holland and Prussia. His studies covered besides specific details and general taxonomy, the consideration of anatomical details of the reptiles and amphibians, the modifications of general organs, geographical distribution, genetic relations and physiological consequences. For five years his publications were devoted almost exclusively to the reptiles and amphibians and through this channel he entered palaeontology, writing in 1865 his first paper in this field, a description of the stegosaurian amphibian called *Amphibamus grandiceps,* and though the scope of his writings widened thereafter to palaeontology, geology, philosophy and even sociology, he never lost sight of his interest in herpetology nor ceased contributing to it.

Theodore Gill has said of Cope: *"He found Herpetology an art; he left it a science; he found it a device mainly for the naming of specimens; he left it the expression of the co-ordination of all structural features."* Cope approached herpetological classification boldly and critically surveyed the work of the authorities of the day, Duméril, Bibron and Günther. Where he saw that changes were needed he calmly proposed that they be made and backed up his suggestions with such sound reasoning that they were adopted.

The anurous amphibians and the saurian reptiles were differentiated in groups, at the time Cope's work began, chiefly on account of superficial characteristics: such as the mode of fixation of the tongue, or its lack; the development of the toes to disklike expansions at the tips, or to simple attenuation; and the presence or absence of teeth. Cope proceeded to investigate the group anatomically and reached new conclusions. He found that important differences existed in the structure of the sternum, especially in the connection of the lateral halves; that in the common tree-toads of Europe and North America the so-called clavicle and coracoid of each side are "connected by a longitudinal arched cartilage which overlaps that of the opposite side" while in the common frogs the clavicles and coracoids of both sides are connected by a single median cartilage. He named the former of these groups, the toads, Arcifers and the latter, frogs, et cetera, Firmisternials and placed the Firmisternials higher in the evolution scale because of their more highly developed shoulder girdle. The development of teeth he first regarded, with his contemporaries, as a very important factor of classification, but later came to subordinate.

Applying his principle of a skeletal basis of classification, Cope dissected the lizards and redistributed them into new divisions, based upon an equation of all skeletal characteristics: such as, structure of the cranium, concordance and variations in the development of bones, structure of the vertebrae, shoulder girdle, teeth, tongue and pholidosis; rather than the previous superficial grouping by tongue form, arrangement of scales, and development of legs and feet. This new method of classification became a matter of bitter correspondence between Cope and the old school herpetologists, but finally won recognition through the sanction of the British Museum catalogues. It crystalized into two volumes which remain, though out-dated, the only comprehensive works on American Herpetology: *The Batrachia of North America,* published in 1889, and the post-mortem complementary volume, *The Crocodilians, Lizards and Snakes of North America.*

## CONTRIBUTIONS TO ICHTHYOLOGY [8]

Cope's contributions to the classification and evolution of the fishes proved to be of such great importance that many of the orders and suborders recognized by him have been adopted by subsequent ichthyologists, especially in America. Beginning with the fresh-water fishes of the Carp family in 1861, he published a series of papers from 1864-1891, including *Partial Catalogue of the Cold-blooded Vertebrata of Michigan; Synopsis of the Cyprinidae of Pennsylvania* and *Observations of the Systematic Relations of the Fishes.* Some of the most interesting genera of North American fresh-water fishes were first made known by him (1864-1869). He attempted to arrange them in natural groups and was the first to appreciate the importance of certain characters, such as the structure of the dorsal fin and the relation of the air-bladder to the digestive tract.

His next great series of contributions (1871-1891) dealt with the natural subdivisions of the entire series of fish-like vertebrates. In these papers the following subjects of major interest were dealt with:

(1) The division of the fishes into classes and subclasses.

(2) The analysis and reclassification of the old and unnatural group of "ganoids."

(3) The division of the higher teleosts, or Actinopteri, into no less than twenty-four orders, eight of which survive today.

(4) The grouping of a series of fresh-water families, including the suckers, carps, loaches, characins, etc., into the order Plectospondyli.

(5) The breaking up of the old unnatural assemblage of eel-like fishes into several orders and many families.

(6) The analysis and classification of the Devonian fossil

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[8] Notes by William King Gregory. For a detailed appreciation, see Gill, Addresses in Memory of Edward Drinker Cope . . . *American Philosophical Society,* November 12, 1897.

fishes generally called crossopterygians into a series of orders and suborders.

Cope's contributions to the fresh-water fishes, like his observations on the snakes and lizards, were based at all points on personal observation of the material and an adventurous spirit in the discovery of new and hitherto neglected anatomical characters of possible value as criteria of classification. His studies on the classification and phylogeny of fishes as a whole were based partly upon a large collection of skeletons of fishes from all parts of the world, which he had purchased from Professor Joseph Hyrtl of Vienna.

Cope's influence in the subsequent development of ichthyology was far greater than would appear on the surface because many of his orders and suborders were adopted with slight modifications in the classification of the fossil fishes in the British Museum by Dr. Arthur Smith Woodward.

## CONTRIBUTIONS TO MAMMALOGY

Cope's most numerous and voluminous writings were devoted to mammals, and to appreciate the importance of his contributions in this group it is necessary to cast a brief glance over the history of mammalian palaeontology. Cuvier, the founder of this branch of science, had represented the *école des faits* in opposition to Geoffrey St. Hilaire, and founded a school wholly opposed to generalization as to the origin and succession of animal life, and firmly adherent to the Special Creation hypothesis. As a master of comparative anatomy, Cuvier exerted an immense influence upon the succeeding French palaeontologists, such as Jourdan, Croizet, Christol, De Blainville, Aymard, Lartet and Pomel. It is true that De Blainville and Gervais showed a wide range of knowledge but Gaudry was the first of the French palaeontologists to grasp the spirit of evolution. In Germany, Jager and Blumenbach ranked as more or less voluminous descriptive writers, while Kaup showed superior powers of analysis.

Cuvier's unnatural classification of the hoofed animals into the *Solipedes*, or horses, and *Pachyderms*, or rhinoceroses and hippopotami, prevailed and was adopted even by Leidy in this country. Richard Owen, by far the greatest anatomist after Cuvier, made a decided advance, and, as in the classification of the fishes and reptiles, was the direct predecessor of Cope. Partly anticipated by De Blainville, he defined the new mammalian orders, *Marsupialia* and *Toxodontia,* and especially broke down Cuvier's classification of the Ungulates by distinguishing the *Perissodactyla* from the *Artiodactyla* upon the basis of foot structure, the importance of which Cuvier himself had only dimly perceived.

In this country the earlier contributions of Jefferson, Harlan and Gibbes were over-shadowed in the mid-century by the numerous valuable works of Leidy, who became at once the founder of American vertebrate palaeontology, although in deference to the theologic spirit of the times he held in check the philosophical spirit both in anatomy and evolution. Thus, from all this long post-Cuvierian period and immense number of facts, there issued only two generalizations, the first of which may be regarded as the great laws or principles in the evolution and classification of the mammalia. These laws are as follows:

I. *The Law of Brain-Growth*—This principle, that the older mammalia had smaller brains, and that in order of succession there was a steady increase in brain size, was enunciated by Lartet, and has been subsequently elaborated and demonstrated by Marsh.

II. *The Classification of the Hoofed Animals by Foot-Structure*—This was discovered by Owen in his division above alluded to, which first directed attention to the importance of differences in the feet.

The three vertebrate palaeontologists of the new period who responded most fully to the Darwinian movements were Huxley, Marsh and Cope. Huxley unwillingly entered the field, but soon found an opportunity of overthrowing Cuvier's Law of Correlation. His greatest generalization was the central position of the order *Insectivora.* He had, however, few opportunities of working upon fossil mammals; he erroneously placed *Paloplotherium* instead of *Hyracotherium* in the ancestral horse line, and erroneously supported Reichert's theory of the homology of the quadrate bones. Cope and Marsh alike responded to the Darwinian impulse but along entirely different lines. In Russia appeared Waldemar Kowalevsky, who had a short but brilliant career in mammalian palaeontology. He announced the third great principle:

III. *Law of Adaptation of Foot Structure in Ungulates by Reduction, Accompanied by Shifting of the Metapodials*—Kowalevsky's ancestral type of ungulate or protungulate, like that of Huxley, was believed to possess five digits.

In the meantime the gifted John A. Ryder, of Philadelphia, was attacking the problems of the mechanical evolution of the feet and teeth from the Lamarckian standpoint.

Cope, who had practically entered mammalian palaeontology in 1870, found a great field of facts lying fallow before him, with the three principles outlined above as means of interpretation. Keen to wed philosophy with anatomy, in 1873 he added to the generalizations of Huxley and Kowalevsky the additional principle:

IV. *The Ancestors of the Hoofed Animals Possessed Bunodont, or hillock-like Teeth*—This prophecy was speedily verified by Wortman's discovery of *Phenacodus*. This discovery led Cope on to a reclassification of the entire group of ungulates by foot-structure—the logical outcome of the movement in which Owen, Huxley, Ryder and himself had participated. This classification centered about the following principle:

V. *The Law of Taxeopody: that the Primitive Feet of Hoofed Animals were Serially Plantigrade, Like those of the Bear, with Serial Unbroken Joints*—Thus he proposed in the early eighties the four new orders, two of which have been permanently adopted into palaeontology: Equivalent to these are three orders proposed by Marsh:

| COPE | MARSH |
|---|---|
| *Taxeopoda*, 1882 | *Protungulata*, 1884 |
| *Amblypoda*, 1875 | *Amblydactyla*, 1884 |
| *Condylarthra*, 1881 | *Clinodactyla*, 1884 |
| *Diplarthra*, 1883 | |

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cular law Cope clearly perceived, but left to others fully to work out and demonstrate. It promises ultimately to give us the key to the entire phylogeny of the mammalia, extending to every division of the marsupialia and placentalia.

Thus the final philosophical working basis for the evolution of the hoofed, as well as the clawed, animals has been well established, for, as Professor Marsh observes in his monograph on Dinocerata, "the characters of the most importance in the evolution of the Ungulates are the teeth, the brain, and the feet."

It now only remained for Cope to take another step beyond Huxley and Kowalevsky and, aided by fortunate discoveries in the field, he demonstrated that the ancestors of the hoofed animals were clawed animals, establishing the seventh law:

VII. *The Hoofed Orders Arise from the Clawed Types of Creodonta and Insectivora.*

So much for the great generalizations which establish Cope's historical position in mammalian palaeontology. These are the mountain peaks, the points where explorations and discovery were followed by happy inspiration, in a chain of contributions which includes his exposition of the faunal succession of the mammals from the base to the summit of the Tertiary, as well as two or three discoveries of great interest in the Cretaceous. His most conspicuous work relates to the Puerco, with its extremely primitive hoofed and clawed animals and primates. Here he established the existence in this country of the *Plagiaulacidae* and defined the order *Multituberculata.* That from the Wasatch is perhaps next in value, and in succession rank his contributions from the John Day, Loup Fork, Blanco, Palo Duro, and Port Kennedy Bone Cave.

## Cope as a Field Explorer

As an explorer he had marked success, finding the unique skeleton of *Hyrachyus,* of *Loxolophodon,* a name which was telegraphed to the American Philosophical Society, and converted by the operator into *Lefalophodon.* He also found the last of the great race of Uintatheres at the top of Washakie

Mountain of central Wyoming. In the Bridger, Cope himself found the lower jaw of *Anaptomorphus,* a little monkey with a dental formula like that of man, which, owing to its extreme antiquity, occasioned him a greater surprise than any discovery he ever made. We owe to him alone our knowledge of the scanty Wind River fauna. From the White River Oligocene his materials were poor and his work less satisfactory. From the rich Upper Oligocene, with the assistance of Wortman, he secured fine collections and has especially enriched our knowledge of the *Anchitheriidae, Felidae* and *Canidae.* From the Upper Miocene, Deep River and Loup Fork beds he has practically originated all that we know, especially of the rhinoceroses, horses, mastodons, camels, and other ruminants and carnivora. Of the latter fauna his most complete papers were upon the evolution of the *Oreodontidae.* His latest contributions to our knowledge of the fossil mammalia were upon the fauna of the Blanco and Palo Duro, or Goodnight beds of Texas, and the rich cave fauna from Port Kennedy, Pennsylvania, brought together by his warm friend, Dr. H. C. Mercer.

The *Tertiary Vertebrata,* Vol. III, of the Hayden quartos, published in 1884, is his most inspiring contribution to palaeontology, including his studies of all the vertebrate fauna of the Tertiary Lakes west of the Rockies. This work of over a thousand pages and seventy-five plates is said to have been the despair of the Public Printer, owing to the constant additions made while in press. It extends from the Puerco to a portion of the lower Miocene fauna. Besides the full description and illustration of the great hoofed orders above alluded to, it contains the full exposition of the characteristic forms of *Creodonta,* an order of primitive Carnivora, which, as we have seen, he separated from the Marsupialia in 1875, and in which he placed six families of mammals from different parts of the world. It will be observed that this volume is entitled "Part I." Cope had in mind a second part which would hardly have been less voluminous. The plates for this part were all prepared and in themselves constituted such an important feature in American palaeontology that at the urgent instance of the present author, they were finally assembled and ably edited with explanatory legends by Dr. William Diller Matthew. They were published by the American Museum of Natural History in 1916, the volumes being distributed with the cooperation of the U. S. Geological Survey.

Before leaving the mammals it is fitting to speak of his Lamarckian work upon "kinetogenesis," or the mechanical origin of the hard parts of the body, especially the teeth, vertebrae, and limbs. An invaluable paper by his friend and later colleague, Ryder, put him upon this line of investigation, the results of which he published in a long series of papers, culminating in his memoir upon the "Origin of the Hard Parts of the Mammalia" and in his collection of essays upon the "Origin of the Fittest" and "Primary Factors of Organic Evolution." One of his chief motives in these researches was the demonstration, which he believed they afforded, of the hereditary transmission of the effects of individual efforts, use and disuse. Even if this Lamarckian motive is subsequently shown to be an illusive one by our future knowledge of the real nature of evolution, these investigations lose little, if any, of their intrinsic value. First, as in all his work, he brings together an immense array of valuable facts and observations; second, he extends the principle of the independent origin of similar structures; third, he in most cases successfully establishes the actual mechanically adaptive or teleological relations of the parts described; fourth, he traces the course of phylogenic modification in a number of important organs and thus establishes certain obscure homologies, notably those in the teeth of *Amblypoda, Coryphodon* and *Uintatherium.*

## CONTRIBUTIONS TO ORNITHOLOGY

Cope was an occasional contributor to the literature of ornithology. He was the first to recognize *Laelaps aquilungus* as the probable link between birds and reptiles. He continued to contribute short descriptions of birds from time to time but never became more than an intelligent and well-informed amateur in ornithology. However, a school essay written at the age of seventeen gives strong indication of an accurate knowledge of the habits of birds and shows that Cope might have developed into a popular bird-man if he had not happened to concentrate his forces in other fields of natural history. In that essay the youth said in part, regarding the Yellow Breasted Chat:

"Often while passing along some retired lane in the country, have I stopped to listen to the singular notes of this bird as they came suddenly upon my ear, like the whistling of the wings of a dove or teal . . . causing me to look up in the expectation of seeing some wild fowl flying off before me. . . . One may readily discover the bird's whereabouts by answering him. . . . He will give you some curious specimens of ventriloquism. His shrill whistle will seem far ahead, when on its ceasing you will be greeted with a note not unlike the half-suppressed croak of an old bull-frog, deep in the thicket beside you; if you stop, he raises his key, almost exactly imitating the call of the partridge, varying it with some deep guttural sounds, much like the barking of young puppies. If you happen to be near his mate and her nest, his anxiety becomes very great; he scolds incessantly, mixing up his whistles and croaks into a most singular jargon of sounds. But if you will sit down on the grass and be right quiet, before long his notes will cease, and if you look carefully under the thicket, you will most likely see him, with his tail up and head down, peering at you with his dark eye, from the lower branch of some sumach. If he finds he is discovered, he becomes more bold and will fly out into the air above your head, where with legs hanging straight down, and tail sticking straight up, he will jerk about, rising pretty high with his short concave wings, and then dropping lower and lower when he glides off into the thicket again. On clear moonlight nights his notes may be heard till long after midnight . . . the country people call him the mocking bird.

"This is perhaps the most difficult bird to shoot that we have. . . . Catesby, an Englishman, who spent some time travelling through the country in the 16th century, in his Natural History of the Colonies, says that he tried his best to obtain specimens himself, but could not, and had to apply to the Indians, who with all their ingenuity found it a difficult matter. . . .

"In size he is somewhat less than the cat bird; the color of his back and wings . . . olive green, and his throat and breast bright yellow. In form he differs from all other birds, excepting an East Indian species with which he is arranged in the genus 'Icteria.' Naturalists differ very widely, as to what family this genus should be referred to. His trivial name, 'polyglotta,' indicates his musical powers."

## CONTRIBUTIONS TO PALAEONTOLOGY[9]

Cope had been diverted from herpetology, as we have seen, by the arrival of *Amphibamus grandiceps* and had swung to an enthusiasm for palaeontology which resulted in his monumental researches, explorations and publications for various State and National Geological Surveys from 1866 until 1897. Beginning in 1866 he was the first to find along the New Jersey coast remains of the leaping dinosaur, *Laeleps aquilunguis,* and he anticipated Huxley in comparing these reptiles with the birds.[10] In 1871 he extended his investigations into the most arid portion of Kansas and there found remains of the ancient marine monsters, the ram-nosed mosasaur, and the sea-serpent or elasmosaur. Following up Custer's army into the Rocky Mountains between the years 1872 and 1878, he discovered in New Mexico, Colorado and Wyoming, the great *Amphicoelias,* the gigantic *Camarasaurus* and the frill-necked *Agathaumas.* In 1877 he received his first fossils from the Permian of Texas and his investigations thereafter revealed a new fauna, rich in species widely different from any previously known.

Working often alone, except for guides, he was obliged to draw his conclusions from fragmentary and imperfect materials and he felt always the necessity of hastening the publication of his findings that he might be the first to herald them. When a bone came into his hands, Professor Cope slowly turned it over and over to thoroughly comprehend its form and to compare it with its nearest ally, then to throw out a conjecture as to its uses and its relation to the life economy of the animal as a whole. He studied the soil and rocks which had entombed the mighty bones, pictured to himself the muscles and nerves which had clothed them and made possible a locomotion to the methods of which the bones themselves bore mute testimony. His mind's eye saw vividly the muddy shores of the

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[9] See, also, Contributions to Mammalogy, Ichthyology, Geology, and Work with Geological Surveys. Also, Osborn, *Impressions of Great Naturalists.*

[10] *Remarks on Extinct Reptiles which approach Birds,* E. D. Cope, *Proc. Acad. Nat. Sci. Phila.* (Vol. XIX) pp. 234, 235. May 11, 1868.

Texas Permian seas where the fin-backed lizards basked, and the great fresh-water expanses of Wyoming and Montana where the dinosaurs wandered. He spoke of these things graphically and today they are visualized in many of our great museums through his inspiration.

## PHYLOGENY OF THE VERTEBRATA

In reconstructing the history of the animals from their bones, Cope, through his great knowledge of anatomy, was also able to connect the ancient species with their modern descendants and to fill in many gaps both in human and animal ancestry. He was fortunate in finding in northwestern New Mexico by far the oldest quadrupeds known at that time, in finding among these the most venerable monkey then known, in describing to the world hundreds of links in the descent of the horses, camels, tapirs, dogs and cats. He worked out (though these views have been modified by later work) the connection between the amphibians and the reptiles and between the amphibians and the true fish, and he was quick as a flash to detect in the paper of some other author the oversight of some link for which he had long been searching.

His final pronouncement of views concerning the phylogeny of the true fishes, amphibians and reptiles was given in the *Proceedings of the American Philosophical Society* for 1892 (pp. 278-281). The ancestral type of the bony fishes was thought to be "probably the Ichthyomous order of the subclass of sharks (Elasmobranchii)." These he selected because "they are hyostylic, and have cranial segmentation, the basioccipital element being conspicuous. The fins are primitive and those of all other types of fishes might have been derived from them." This view is now being modified by the opinion that much of the simplicity of the sharks is degenerate; the Ichthyotomi are now considered as probably the most primitive of known sharks, but too definitely elasmobranchs to be ancestral to the teleostomes and the two are thought to be of equal antiquity palaeontologically.

There remained some doubt in Cope's mind as to the probable ancestry of the batrachia and he remarked "that it cannot be considered to be yet settled." He was at first a supporter of the Haeckelian belief that they had been derived from the Dipnoi or Dipneusta, but later discarded this theory in favor of Theodore Gill's proposal of the Crossopterygians. He suggested particularly the Rhipidopterygia, in which he included the families of Holoptychiidae, Tristichopteridae, Osteolepididae, Coelacanthidae, "and perhaps some others." The origin of the amphibia is now sought in or near the crossopterygians and the osteolepids are believed to be closest to this ancestry of any known forms.

He was less cautious about the reptiles, which at that time were admittedly differentiated from the amphibian stock, although the exact point of departure remained in obscurity, and concluded that the batrachians which were nearest to the reptiles were the "Emblomeri of the Permian epoch." It is now usually accepted that the Emblomeri among the amphibians are closest to the reptiles, perhaps because this term is used for a grade of structure which appears to be primitive for amphibia, but the origin of reptiles is now sought farther back than the Permian.

As to his scientific attainment in the field of taxonomy or classification, apart from his genius, which is indefinable, we signalize his appreciation of the most significant or diagnostic character in a group. Among his fellow-workers in the same field, whether upon the fishes, amphibians, or mammals, he was quick to comprehend and seize upon a strategic position. While others were plodding on serenely in the description of facts, giving all an equal value, Cope, with an eagle eye, would swoop down upon some great distinctive fact and point out its supreme importance. Thus he projected the mammalian order, *Creodonta*, out of numerous forms, such as *Palaeonictis, Hyaenodon, Arctocyon,* which had been discovered and studied for many years in France. It is to be regretted that he did not more willingly surrender some of his own hypotheses. He clung to his erroneous mechanical explanation of the origin of ungulate foot structure long after it had been disproved by the present writer. Like all of us, perhaps, he loved his own hypotheses, and he once observed in jest in regard to a fossil which had opposed one of his theories, "I wish you would throw that bone out of the window."

He was no respecter of authority *per se*. Even if sometimes mistaken, his fearless criticisms were chiefly animated by high ideals and readiness to change the existing order of things. He was full of cheer and determination when things looked most unpromising, allowing nothing to disturb the composure which is so essential to research.

## CONTRIBUTIONS TO SOCIOLOGY

As the Copes' only child, Julia, grew up her father became interested in the education of women and through that subject in various other sociological problems. He proceeded to publish his opinions. He believed that women, being the mothers of the race and equal contributors to its development, should enjoy opportunities for intellectual development equal to those of men.[11] He sent his daughter to Miss Burnham's School at Northampton, Massachusetts, stipulating that she should study as much science as possible. Later, in 1885, he transferred her studies to the newly-opened Bryn Mawr College where Woodrow Wilson and other recent graduates of the Johns Hopkins University were young professors. He continually admonished his daughter to study, telling her that the best beloved woman was she who combined beauty with intelligence and an informed mind.

That woman of any race, however, is predestined to a physical and mental inferiority to the man of her own race Cope firmly stated; giving the physical disabilities as "inferior muscular strength and child-bearing"; and the mental disabilities as "inferior mental co-ordination, and greater emotional sensibility which interferes more or less with rational action." He stated the differences between the sexes as follows:[12]

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[11] *The Relation of the Sexes to Government,* E. D. Cope. Popular Science Monthly, October, 1888.

> "The struggle with Nature has given the male of man superior muscular strength and superior rationality. Both have been forced upon him, the first by exertion, the second by experience. Necessity has also compelled him to undergo labor of body and of mind for long continued periods, so that his powers of endurance have been cultivated. Knowing the danger of physical conflict with his kind, he has learned to exercise a certain control of his manners and language. As regards women, their maternal instinct and the care of children have cultivated their affections rather than their rational faculties. Their occupations, although often laborious, have been generally less severe than those of men; hence results their inferior muscular strength, which is from two-thirds to one-half that of a man of the same race and condition. Their affectional nature has led women to cultivate the aesthetic and to excel in the adornment of their persons and their homes. For natural reasons they have become more cleanly than man, more refined, and more attentive to small matters. The general effect of the preponderance of the emotional element in the female mind is to render it more liable to the temporary loss of the coordinate action of its parts, than in the man. This fact is illustrated in the greater ease with which women fall into tears, syncope, hysteria, etc. On the other hand women learn many things with great facility, and are quite as skillful in the use of languages as men."

Cope opposed woman suffrage, because he regarded man as woman's natural protector and legislator, because he believed the suffrage should be restricted rather than increased in any case, and because he doubted woman's power of becoming a serious economic or political factor. They would vote through emotional suasion either with or against their husbands and lovers, he thought, and similarly in economics, although some women might be successful in business or professional undertakings, even they would be dependent upon capital produced by masculine effort. Woman suffrage he therefore discarded as an unnecessary promoter of family quarrels, of which there were sufficient causes already, and an instigator of sexual discord which would react evilly upon the race through the deterioration of feminine attributes.

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[12] *The Marriage Problem,* by Prof. E. D. Cope; published from The Open Court of November 15 and 22, 1888, by A. E. Foote, 1223 Belmont Avenue, Philadelphia, 1888.

Regarding marriage Cope was very advanced. He approached the problem almost as a physician approaches the sick, and begged for as calm and unprejudiced a view of the situation as possible. He believed in monogamy as the best economic and psychological adjustment of the biologic problem to civilization. He believed that when monogamy failed two root causes were culpable: mental, spiritual and physical ignorance; and serious divergencies of character and conduct due to ancestry and education. His first reform of the marriage laws concerned unions which involved insane persons, habitual drunkards, and drug addicts: to these when single he would forbid marriage, and when married he would enforce separation "for the all-sufficient reason that such unions cause a great deterioration of the race."

Of normal marriage he remarked: "Eighteen hundred years of Christianity finds us in as great difficulties as ever, but with our sense of justice quickened and our sympathies developed. We have as a basis the fact that most of the white race at least, are capable of a generous and self-sacrificing intersexual passion, which, if treated with reasonable consideration, is of lasting character." Taking this view and the acknowledged failures of the existing system as a starting point, Cope stated his premise: "What is necessary is that matrimonial changes shall be removed from the domain of caprice, and shall be only permitted after a full and fair trial," and expounded his golden mean: the contract marriage. This solution provided for three arbitrarily successive contracts; to have the same value and effect as the existing marriage contract and the same bearing upon support, property and divorce as the laws then prevailing in Pennsylvania, which Cope cited as the most liberal in the country. The time limits of the contracts should increase so as to prevent women of mature age from being deprived of support: the first contract, for previously unmarried persons, should endure for five years and should be renewable only at the desire of both parties; the second contract should then run for ten or fifteen years and should lapse only at the desire of both parties; the third contract for permanent relations should then be available. In cases of second marriage the longest contract next in order for either party should be obligatory, except in cases where one person had hitherto been unmarried when the previous time contract of the other should be duplicated for the new marriage. Divorce at the expiration of a contract should be granted without publicity, the custody of children being settled as under prevailing laws. A man should be held responsible for the support of his children after divorce, but not of his wife if she be childless. In that case, as her divorce was of her own choosing, she should support herself or be supported by her family.

Throughout the discussion of the marriage problem, education and suffrage, Cope was insistently the biologist, interpreting his sociology by the laws of nature and led to optimism by his belief in evolution. He was an intense Lamarckian and stated in his *"Origin of the Fittest,"* "I have learned the connection between the motion of animals and the development of their structure by my studies of palæontology. It is a satisfaction to me to be able to prove the fatherhood of mind or living personality over living nature. It will be the next step to prove that it has been so over dead nature, also. . . . In the proper way and at the proper time mind controls. To find out how this is and when and where, is the great problem of science, also therefore of progress and prosperity."

Cope was a theist in evolution, probably because so long as his orthodox Quaker father lived he was continually requested to reconcile his theories with the religious views in which he had been strictly trained. His affection for his father and his real devotion to a faith, which was after all less troubled by dogma than many sects of his generation, helped him. In fact he justified his early acceptance of the Darwin theory in 1871 as a "Shaker of false faiths and an aid to that which is founded on a rock, that that which cannot be shaken may remain." After his father's death he began to feel that the need of curtailing his views to avoid controversy and scandal in a small circle was too severe a strain upon his adventurous imagination. He accordingly resigned from the Society of Friends in 1878, but remained a theist in philosophy and a creative evolutionist in scientific theory.

## CONCLUSION

The most conspicuous feature of Cope's character from boyhood upward was independence; seldom has a face reflected a character more fully. His square and prominent forehead suggested his vigorous intellect and marvelous memory; his brilliant eyes were the media of exceptional keenness of observation; his prominent chin was in traditional harmony with his aggressive spirit. From this rare combination of qualities so essential to free investigation sprang his scientific genius.

Appreciation of greatness is a mark of the civilization and culture of a people. Cope's monumental work, preserved in thousands of notes, short papers, and memoirs, and in three bulky government quartos, constitutes his assurance of enduring fame. Some of his countrymen, and even of his fellow-workers, allowed certain of his characteristics to obscure his stronger side in their estimate of him and his works, and during his life he received few of the honors such as foreigners are wont to bestow upon their countrymen of note. When we think more deeply of what really underlies human progress, we realize that only to a few men with the light of genius is it given to push the world's human thought along, and that Edward Drinker Cope was one of these men.

We may contrast three great Academicians: Joseph Leidy, Edward Drinker Cope and Othniel Charles Marsh. Whereas in Leidy we had a man of the exact observer type, Cope was a man who loved speculation. If Leidy was the natural successor of Cuvier, Cope was the natural successor of Lamarck. Leidy, in his contributions to the academy, covered the whole world of nature, from the Protozoa and Infusoria up to man, and he lived as the last great naturalist in the world of the old type who was able by both capacity and training to cover the whole field of nature. Cope, in contrast, mastered—and this mastery in itself was a wonderful achievement—the entire domain of vertebrates from the fishes up. Marsh, with less breadth and less ability, nevertheless was a palaeontologist of a very high order and had a genius for appreciating what might be called the most important thing in science. He always knew where to explore, where to seek the transition stages, and he never lost the opportunity to point out at the earliest possible moment the most significant fact to be discovered and disseminated.

It is most interesting to contrast the temperament of these three men, Joseph Leidy, Edward Drinker Cope and Othniel Charles Marsh. They were as different as any three men could possibly be made, both by nature and nurture. As Professor Edward Smith said, in one of his addresses on Leidy, "scientists are only mortals after all." Your scientific genius may hitch up with a star on one hand and with an anchor on the other. Whereas Leidy was essentially a man of peace, Cope was what might be called a militant palaeontologist; whereas Leidy's motto was peace at any price, Cope's was war whatever it cost. I do not know that I can find from Shakespeare any characterization of Joseph Leidy, but I think in *Henry IV* there is a very apt characterization of my friend Edward D. Cope:

> I am not yet of Percy's mind, the Hotspur of the north; he that kills me some six or seven dozen of Scots at a breakfast, washes his hands and says to his wife, "Fie upon this quiet life! I want work."

Perhaps there was a scientific providence in all this; perhaps such antagonistic spirits were necessary to enliven and disseminate interest in this branch of science throughout the country. The subtle combative quality in a palaeontologist is a strange quality; it is a strange inversion, because the more ancient and difficult the study, the more refractory the fossil, the greater the animation of discussion regarding its relationships. From this subtle ferment there arose the famous rivalry which existed not between Leidy and either of the others, because it was impossible to quarrel with Leidy, but between Cope, the descendant of a Quaker family, and Marsh the nephew of a great philanthropist. This rivalry was tonic to Cope and although in his eagerness to publish his discoveries and theories before Marsh could produce similar material he made careless mistakes, still "the scowl of his foe" (Marsh) remained, as in the Celtic poem, "the sun which caused him to grow."

# Bibliography of Edward Drinker Cope

## 1859-1915

BY HENRY FAIRFIELD OSBORN AND ASSISTANTS

## INTRODUCTION

This bibliography has been rearranged from the manuscript copy of a "Bibliography of the Published Writings of Edward Drinker Cope, 1859-1899," by Anna M. Brown.

In the revision material from the bibliography included in Dr. O. P. Hay's "Bibliography and Catalogue of the Fossil Vertebrata of North America,"[1] and Persifor Frazer's "Catalogue chronologique des publications de Edward Drinker Cope"[2] has been incorporated. Indebtedness must also be acknowledged to Mr. F. W. Ashley of the Library of Congress, to Dr. Witmer Stone of the Academy of Natural Sciences of Philadelphia, to Dr. W. P. Wilson of the Commercial Museum, Philadelphia, to Mr. John Ashurst of the Free Library of Philadelphia, and to Mr. Charles W. Johnson of the Boston Society of Natural History who have most kindly helped both to verify and to locate references.

In the arrangement of the titles an effort has been made to keep to the following rules:

- I. Dates
  - A. So far as can be ascertained the titles are arranged in chronological sequence in accordance with their respective dates of publication.
    - 1. Dates of publication are taken from

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[1] Bibliography and Catalogue of the Fossil Vertebrata of North America. *Bull. U. S. Geol. Survey,* No. 179, 1902.

[2] Catalogue chronologique des publications de Edward Drinker Cope . . . *Extrait, Annales Soc. géol. de Belgique,* t. XXIX, Bibliographie, pp. BB3-BB77. Liége, 1902.

a. Dates on the brochures.
b. Dates published by the Academy of Natural Sciences of Philadelphia in "Index to the Scientific Contents of the Journal and Proceedings of the Academy of Natural Sciences of Philadelphia. Published in Commemoration of the Centenary of the Academy, March 21, 1912."
c. Dates of acknowledgment for the various parts of the publications of the American Philosophical Society as published in their Proceedings.

B. In cases where an article has appeared in instalments covering two or more months the *date of the first instalment* has been adopted.

C. When no date of publication could be found
1. Verbal communications were listed under the dates of the proceedings.
2. Volumes were placed at the beginning of the year.
3. Those titles having the month but not the day of publication were placed at the beginning of the month.

D. Dates following volumes are those of the year in which the verbal proceedings were held. When there is a discrepancy between this date and the one selected as the index date, the latter is, to the best of belief, that of actual publication.

E. An abstract of an article appearing previous to the publication of the full article is separately listed. (See, II C.)

F. Titles found in the manuscript but impossible to locate and undated manuscripts of Cope's have been placed together, without numbers, at the beginning of the bibliography.

II. Titles

A. Published titles stand as printed save for uniformity of capitalization.

B. Verbal communications and untitled editorials are titled as follows:
1. According to the titles published in the indices of the volumes, except in cases where the title failed to agree with the subject of the communication.
2. According to some title published later as in the "Index" of the Academy.
3. By supplying a title enclosed in ( ), using in almost all cases those in Miss Brown's bibliography.

C. Titles of abstracts, when changed from but of *later date of publication* than the original are indicated under the original article.

III. Abbreviations

A. The titles of all publications are abbreviated in accordance with the schemes most commonly used.

*e. g.* Amer. Journ. Sci.—American Journal of Science
Amer. Nat.—American Naturalist
Ann. & Mag. Nat. Hist.—Annals and Magazine of Natural History
Bull. U. S. Nat. Museum.—Bulletin of the United States National Museum
Bull. Geol. Soc. Amer.—Bulletin of the Geological Society of America
Journ. Acad. Nat. Sci. Phila.—Journal of the Academy of Natural Sciences of Philadelphia
Lippincott's Mag.—Lippincott's Magazine
Nat. Hist. Rev.—Natural History Review (published in London)
Pal. Bull.—Paleontological Bulletin
Proc. A. A. A. S.—Proceedings of the American Association for the Advancement of Science
Proc. Acad. Nat. Sci. Phila.—Proceedings of the Academy of Natural Sciences of Philadelphia
Proc. Amer. Philos. Soc.—Proceedings of the American Philosophical Society
Proc. U. S. Nat. Museum—Proceedings of the United States National Museum
Proc. Boston Soc. Nat. Hist.—Proceedings of the Boston Society of Natural History
Proc. Zool. Soc.—Proceedings of the Zoological Society of London
Smithsonian Contrib. to Knowledge—Smithsonian Contributions to Knowledge
Southern Mag.—Southern Magazine
Trans. Acad. Nat. Sci. Phila.—Transactions of the Academy of Natural Sciences of Philadelphia
Trans. Amer. Entomol. Soc.—Transactions of the American Entomological Society
Trans. Amer. Philos. Soc.—Transactions of the American Philosophical Society.
Zool. Anz.—Zoologischer Anzeiger

1. In cases such as the Annals and Magazine of Natural History and the American Journal of Science where the title of the publication has undergone change the title now in use is the one chosen throughout the bibliography.

B. Miscellaneous abbreviations

1. (Hay) means that the preceding note or succeeding title is quoted in Hay's "Bibliography and Catalogue of the Fossil Vertebrata of North America."
2. * means not personally seen

## TITLES OF E. D. COPE, NOT DISCOVERED, JULY 1, 1921

Some Points in the Zoology and Geology of Glycaphuatl, by Robert Ramrod, A. E. C.

A Satire on the Philadelphia Academy. Evidently seen by Persifor Frazer since it is quoted by him in the *American Geologist,* Vol. 26, 1900, pp. 70, 71. No trace could be found.

ORGANIC MATTER

Supposed to be in the *New Review* (Philadelphia), Vol. I, No. 3, Sept. 19, 1895, pp. 20, 21. Not in the publication.

BIOLOGY

Supposed to be in the *New Review* (Philadelphia), Vol. II, No. 1, 1896, p. 212. Not in the publication.

A Bibliography of the Chelonia (MSS.). Now in possession of the Osborn Library of Vertebrate Paleontology.

A collected volume of manuscript. Contents: Catalogue of Reptilia of the Upper Amazon.

## BIBLIOGRAPHY

1859.1 April 26 On the Primary Divisions of the Salamandridæ, with Descriptions of Two New Species. *Proc. Acad. Nat. Sci. Phila.* Vol. XI, 1859, pp. 122-128.

An annotated synopsis of the subfamilies and genera with descriptions of the new species *Amblystoma conspersum* and *Desmognathus ochrophaea* from Pennsylvania.

1860.2 Jan. 12 Notes and Descriptions of Foreign Reptiles. *Proc. Acad. Nat. Sci. Phila.* Vol. XI, 1859, pp. 294-297.

Tortoises and a crocodile from West Africa, including the new genus *Heptathyra* of the former and a new genus of snake, *Olisthenes,* from South America.

.3 March 30 Catalogue of the Venomous Serpents in the Museum of the Academy of Natural Sciences of Philadelphia, with Notes on the families, genera and species. *Proc. Acad. Nat. Sci. Phila.* Vol. XI, 1859, pp. 332-347.

.4 April 13 Supplement to "A Catalogue of the Venomous Serpents in the Museum of the Academy of Natural Sciences of Philadelphia." *Proc. Acad. Nat. Sci. Phila.* Vol. XII, 1860, pp. 72-74.

With a key to the genus *Elaps,* and a description of a new species, *Elaps melanogenys.*

.5 April 13 Catalogue of the Colubridæ in the Museum of the Academy of Natural Sciences of Philadelphia. Part I. Calamarinæ. *Proc. Acad. Nat. Sci. Phila.* Vol. XII, 1860, pp. 74-79.

Including description of the new genus *Tropidoclonion* and several new species.

.6 Nov. 15 Catalogue of the Colubridæ in the Museum of the Academy of Natural Sciences of Philadelphia, with Notes and Descriptions of New Species. Part II. *Proc. Acad. Nat. Sci. Phila.* Vol. XII, 1860, pp. 241-266.

Describing the new genera *Pariaspis, Cemophora, Hypsiglena, Coniophanes* Hallowell MSS., *Pliocerus* and *Eumesodon.*

.7 Nov. 15 Notes and Descriptions of New and Little Known Species of American Reptiles. *Proc. Acad. Nat. Sci. Phila.* Vol. XII, 1860, pp. 339-345.

Mostly from the Xantus collection from Lower California. A new genus of snake, *Chilomeniscus,* is described from that peninsula.

.8 Dec. An Enumeration of the Genera and Species of Rattlesnakes, with Synonymy and References. *Smithsonian Contrib. to Knowledge,* Vol. XII, 1860, Art. VI, Appendix A, pp. 119-126.

Including the first mention, from MSS. (without description), of Kennicott's *Crotalus lepidus.*

1861.9 Jan. 18 Descriptions of Reptiles from Tropical America and Asia. *Proc. Acad. Nat. Sci. Phila.* Vol. XII, 1860, pp. 368-374.

Including the new family *Adenomidæ* and genus *Ademonus* from Ceylon, the new skink, *Siderolampsus* from Mexico and the new snake genus *Amastridium* from New Granada (Colombia).

.10 Jan. 18 Report upon the Reptiles of the North Pacific Exploring Expedition under Command of Capt. John Rogers, U. S. N., by Edward Hallowell (E. D. Cope, editor). *Proc. Acad. Nat. Sci. Phila.* Vol. XII, 1860, pp. 480-510.

Collections of reptiles and amphibians from Nicaragua, California, Oceania (Hawaiian Islands), New Holland (Australia), Loo-Choo, Japan, China, Java, Cape of Good Hope, and Madeira, with an index of species.

.11 March 31 Descriptions of New Species of the Reptilian Genera *Hyperolius, Liuperus* and *Tropidodipsas.* *Proc. Acad. Nat. Sci. Phila.* Vol. XII, 1860, pp. 517, 518.

From Liberia, Buenos Aires and Honduras, respectively.

.12 List of the recent species of Emydosaurian Reptiles in the
March Museum of the Academy of Natural Sciences. *Proc. Acad.*
31 *Nat. Sci. Phila.* Vol. XII, 1860, pp. 549, 550.
With descriptions of a new genus *Osteolaemus* of the *Crocodilidæ* from West Africa, and a new snake, *Mecistops bathyrhynchus* of unknown locality.

.13 Catalogue of the Colubridæ in the Museum of the Academy
March of Natural Sciences of Philadelphia. Part III. *Proc. Acad.*
31 *Nat. Sci. Phila.* Vol. XII, 1860, pp. 553-566.
Including descriptions of the new genera *Prymnomidon* from Siam and *Zaocys* from Ningpo, China.

.14 Remarks on Reptiles (Changes in Nomenclature: Species of
June *Tantilla:* Specific Characters of *Lepidosternum floridanum*).
30 *Proc. Acad. Nat. Sci. Phila.* Vol. XIII, 1861, pp. 73-75.
Gives a synopsis of the genus *Tantilla.*

.15 Remarks on Reptiles (*Diphalus: Amphisbaena angustifrons:*
June *Loxocemus* Cope). *Proc. Acad. Nat. Sci. Phila.* Vol. XIII,
30 1861, pp. 75-77.
West Indies, Buenos Aires and San Salvador.

.16 On an Iguana from Andros Island. *Proc. Acad. Nat. Sci.*
Sept. *Phila.* Vol. XIII, 1861, p. 123.
30 *Cyclura bacolopha* Cope.

.17 On Amblystoma from Chester Co., Pennsylvania. *Proc.*
Sept. *Acad. Nat. Sci. Phila.* Vol. XIII, 1861, pp. 123, 124.
30 A new species of Amblystoma, *Amblystoma microstomum,* from Ohio.

.18 Notes and Descriptions of Anoles. *Proc. Acad. Nat. Sci.*
*Phila.* Vol. XIII, 1861, pp. 208-215.
The Academy of Natural Sciences of Philadelphia acknowledges no month for this signature. A preliminary paper on the anoline Squamidæ mostly from Cuba.

.19 Contributions to the Ophiology of Lower California, Mexico
Dec. and Central America. *Proc. Acad. Nat. Sci. Phila.* Vol.
28 XIII, 1861, pp. 292-306.
With some general remarks on distribution and the dividing line between the neotropical and nearctic groups of faunæ.

.20 On the Reptiles of Sombrero and Bermuda. *Proc. Acad.*
Dec. *Nat. Sci. Phila.* Vol. XIII, 1861, pp. 312-314.
28 A description of two new species *Ameiva corvina* and *Plestiodon longirostris.*

1862.21 March 31 On the Genera *Panolopus*, *Centropyx*, *Aristelliger* and *Sphaerodactylus*. *Proc. Acad. Nat. Sci. Phila.* Vol. XIII, 1861, pp. 494-500.

With a synopsis of species.

.22 March 31 Observations upon certain Cyprinoid Fish in Pennsylvania. *Proc. Acad. Nat. Sci. Phila.* Vol. XIII, 1861, pp. 522-524.

*Chrosomus eos* and *Leucosomus rhothius* (*Cyprinella analostana* Gerard of Potomac basin) found in Susquehanna basin.

.23 March 31 On *Elapomorphus*, *Sympholis*, and *Coniophanes*. *Proc. Acad. Nat. Sci. Phila.* Vol. XIII, 1861, p. 524.

Dividing *Elapomorphus* into three genera *E.*, *Phalotris* and *Apostolepis*. Specimens described from Paraguay and Guadalaxara, Mexico.

.24 April 25 On the Dentition of *Herpeton tentaculatum*, and on the Habitat of *Gerarda prevostiana* and *Rhabdosoma lineatum*. *Proc. Acad. Nat. Sci. Phila.* Vol. XIV, 1862, p. 1.

From Siam, Philippine Islands (?) and Trinidad, respectively.

.25 April 25 Synopsis of the Species of *Holcosus* and *Amevia*, with Diagnoses of new West Indian and South American Colubridæ. *Proc. Acad. Nat. Sci. Phila.* Vol. XIV, 1862, pp. 60-82.

The H. and A. from West Indies, Central and South America.

.26 April 25 On some New and Little Known American Anura. *Proc. Acad. Nat. Sci. Phila.* Vol. XIV, 1862, pp. 151-159.

From Cuba, New Providence Isl., St. Thomas, New Grenada (Colombia), Paraguay, Panama and Nicaragua.

.27 Contributions to Neotropical Saurology. *Proc. Acad. Nat. Sci. Phila.* Vol. XIV, 1862, pp. 176-188.

The Academy of Natural Sciences acknowledges no date (month or day) for these pages. See the "Index," p. xiii. From New Grenada (Colombia), Paraguay, Central America and the West Indies. With a synopsis of the skink genus *Mabuia*.

.28 On *Neosorex albibarbis*. *Proc. Acad. Nat. Sci. Phila.* Vol. XIV, 1862, pp. 188, 189.

The Academy of Natural Sciences acknowledges no date (month or day) for these pages. See the "Index," p. xiii.

.29 On *Lacerta echinata* and *Tiliqua dura*. *Proc. Acad. Nat. Sci. Phila.* Vol. XIV, 1862, pp. 189-191.

The Academy of Natural Sciences acknowledges no date (month or day) for these pages. See "Index," p. xiii. Both from West Africa. Other additions to the "Catalogues of West African reptiles recently published by Drs. Gray and Duméril."

.30 On *Carphotis harpesti. Proc. Acad. Nat. Sci. Phila.* Vol. XIV, 1862, p. 249.

The Academy of Natural Sciences acknowledges no date (month or day) for these pages. See the "Index," p. xiii. A specimen of this Dum. and Bib. species discovered in Texas is placed in the genus *Virginia.*

.31 Oct. 28 Notes upon some Reptiles of the Old World. *Proc. Acad. Nat. Sci. Phila.* Vol. XIV, 1862, pp. 337-344.

.32 Oct. 28 On a Cuban Bufanoid: *Peltaphryne empusa. Proc. Acad. Nat. Sci. Phila.* Vol. XIV, 1862, p. 344.

First characterization of this genus.

.33 Oct. 28 Catalogue of the Reptiles obtained during the Explorations of the Parana, Paraguay, Vermejo and Uraguay Rivers, by Capt. Thos. J. Page, U. S. N.; and of those procured by Lieut. N. Michler, U. S. Top. Eng., Commander of the Expedition conducting the Survey of the Atrato River. *Proc. Acad. Nat. Sci. Phila.* Vol. XIV, 1862, pp. 346-359.

With a synopsis of the Bufonidæ.

1863.34 April 3 On Trachycephalus and on South American Batrachia. *Proc. Acad. Nat. Sci. Phila.* Vol. XV, 1863, p. 26.

*Corneöus* thickening on interior metatarsus of *Trachycephalus* during breeding season. Manubrium sterni present in certain South American Bufones.

.35 May On Part II of Prof. G. Jan's Prodromo della Iconografia Generale degli Ofidi. [Review]. *Amer. Journ. Sci.,* 2d Ser. Vol. XXXV, 1863, pp. 455-458.

Discussion and corrections on Calamaridæ and a new synopsis of the Probletorhinidæ.

.36 June 8 On *Hololepis simus. Proc. Acad. Nat. Sci. Phila.* Vol. XV, 1863, p. 42.

New species from Cedar Swamps, New Jersey.

.37 June 8 On *Trachycephalus, Scaphiopus* and other American Batrachia. *Proc. Acad. Nat. Sci. Phila.* Vol. XV, 1863, pp. 43-54.

Mostly from Tropical America. Synopses of Trachycephalus and Scaphiopus.

.38 On a Species of Vipera hitherto unknown. *Proc. Zool. Soc.*
June 1863, pp. 229, 230, one figure. (Reprinted, *Ann. & Mag.*
9 *Nat. Hist.*, 3d. Ser., Vol. XIII, 1864, pp. 181, 182, one
figure).

*V. confluenta.*

.39 Descriptions of new American Squamata, in the Museum of
July the Smithsonian Institution, Washington. *Proc. Acad. Nat.*
13 *Sci. Phila.* Vol. XV, 1863, pp. 100-106.

Mostly from Tropical America including several of Xantus' specimens from Cape St. Lucas, Lower California.

1864.40 Contributions to the Herpetology of Tropical America. *Proc.*
Sept. *Acad. Nat. Sci. Phila.* Vol. XVI, 1864, pp. 166-181.
30

.41 On the Limits and Relations of the Raniformes. *Proc. Acad.*
Sept. *Nat. Sci. Phila.* Vol. XVI, 1864, pp. 181-183.
30

.42 On the Characters of the Higher Groups of Reptilia Squa-
Sept. mata—and especially of the *Diploglossa*. *Proc. Acad. Nat.*
30 *Sci. Phila.* Vol. XVI, 1864, pp. 224-231.

.43 On a Blind Silurid, from Pennsylvania. *Proc. Acad. Nat.*
Sept. *Sci. Phila.* Vol. XVI, 1864, pp. 231-233.
30 *Gronias nigrilabris* Cope N. Sp. with rudimentary eyes, and *Ethostoma peltatum* Stauffer N. Sp., from Conestoga Creek, Lancaster Co., Pa. *Pœcilichthys mesœus* Cope N. Sp. from Platte River, Fort Kearney, Neb.

1865.44 Sketch of the Primary Groups of *Batrachia salientia*. *Nat.*
Jan. *Hist. Rev.* (London), Vol. V, 1865, pp. 97-120.
?

.45 Partial Catalogue of the Cold-Blooded Vertebrata of Mich-
Feb. igan. *Proc. Acad. Nat. Sci. Phila.* Vol. XVI, 1864, pp.
13 276-285.

From collections of the Flint Scientific Institute, the State Agricultural College. Several new species. Several specimens from Pennsylvania and Kansas discussed in footnotes.

.46 Partial Catalogue of the Cold-Blooded Vertebrata of Mich-
Aug. igan. Part II. *Proc. Acad. Nat. Sci. Phila.* Vol. XVII,
7 1865, pp. 78-88.

Continuation of preceding. Several new species described in footnotes. On p. 85 "Note on fishes brought from Platte River, near Fort Riley, by Dr. Wm. A. Hammond." On pp. 87-88 "Supplementary note on a peculiar genus of Cyprinidæ—*Ericymba buccata* Cope, N. G. et Sp."

.47 Oct. 16 On *Amphibamus grandiceps,* a new Batrachian from the Coal Measures. *Proc. Acad. Nat. Sci. Phila.* Vol. XVII, 1865, pp. 134-137.

This is Cope's first palaeontological contribution. Moodie remarks,[13] "The publication of the type species of this genus began the researches of Professor Cope on the extinct amphibia of North America, which he continued for so many years with such excellent results. The description was based on a single specimen, belonging to Mr. Joseph Evans of Morris, Illinois, who loaned it to Dr. Worthen for the Illinois Geological State Survey, in order that it might be described. The type has been destroyed by fire; so I am informed by Mr. L. E. Daniels of Rolling Prairie, Indiana. There are two other known specimens of the species. One is in the collection of Mr. Daniels, and the other No. 794 of the Yale University Museum." The genus is an important one among fossil amphibia and is made by Dr. Moodie the type of a distinct family.

.48 Oct. 16 Note on a Species of Whale occurring on the Coasts of the United States (Title given in Index for Vol. XVII, as follows: Note on a Species of Whale caught in the River Delaware). (*Balæna cisarctica.*) *Proc. Acad. Nat. Sci. Phila.* Vol. XVII, 1865, pp. 168, 169.

.49 Dec. 26 Note on a Species of Hunchback Whale. *Proc. Acad. Nat. Sci. Phila.* Vol. XVII, 1865, pp. 178-181.

*Megaptera osphyia.*

.50 Dec. 26 Third Contribution to the Herpetology of Tropical America. [Frazer (1902) added to this title the following sub-title:—With a Synopsis of the Genera *Hylidae.*] *Proc. Acad. Nat. Sci. Phila.* Vol. XVII, 1865, pp. 185-198.

With a list of species sent by Dr. Sartorius to the Smithsonian Institution from near Vera Cruz and the table-land and southern mountains of Mexico. Also a synopsis of the genera of Hylidæ.

.51 Dec. 26 A Contribution to a Knowledge of the *Delphinidæ. Proc. Acad. Nat. Sci. Phila.* Vol. XVII, 1865, pp. 198-204.

1866.52 Supplement to the Description of Vertebrates. *Geological Survey of Illinois,* A. H. Worthen, Director, Vol. II, 1866, pp. 135-141, Pl. XXXII and 1 woodcut.

*Amphibamus grandiceps* redescribed and figured. See 47.

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[13] Moodie, R. L., 1916, The Coal Measures Amphibia of North America. Carnegie Institution Publication No. 238, p. 126.

.53 Observations on the Skeleton of a Seal, and on the Crania of Cetaceans of the United States Coast, with Remarks on the Species of the Latter. *Proc. Acad. Nat. Sci. Phila.* Vol. XVII, 1865, pp. 273, 274.

The original, verbal communication, is not indexed. The title was given by Frazer (1902), but in the Index of the Academy (1913) the title is given as: On a Species of Seal and on Cetaceans. No date of publication acknowledged by the Academy of Natural Sciences, see, "Index," p. xiii. It seems obvious that the more likely date for this signature is early in 1866, since the preceding signature was dated December 26, 1865, and the subsequent signature for the earliest part of Vol. XVIII is acknowledged June 11, 1866.

.54 Observations on the Geographical Distribution of Some Fresh-water Fishes. *Proc. Acad. Nat. Sci. Phila.* Vol. XVII, 1865, p. 274.

No date of publication acknowledged by the Academy of Natural Sciences. See 53, note. Untitled verbal communication. Present title given by Frazer (1902). Changed in the Index (1913) to: On Geographical Distribution of Certain Fishes. Contrast in fish faunas of Coastal Plain and Piedmont of Atlantic Slope of U. S.

.55 Second Contribution to a History of the Delphinidæ. *Proc. Acad. Nat. Sci. Phila.* Vol. XVII, 1865, pp. 278-281.

No date of publication acknowledged by the Academy of Natural Sciences. See 53, note.

.56 June 11 Remarks on a Species of Nautilus, *Aturia,* from the New Jersey Cretaceous. *Proc. Acad. Nat. Sci. Phila.* Vol. XVIII, 1866, pp. 3, 4.

Title in Index: On an Aturia from the Marl of New Jersey.

.57 June 11 Description of the cranium of a Black-Fish from Delaware Bay. *Proc. Acad. Nat. Sci. Phila.* Vol. XVIII, 1866, pp. 7, 8.

(*Globicephalus.*)

.58 July On the Structures and Distribution of the Genera of the Arciferous Anura. *Journ. Acad. Nat. Sci. Phila.,* Ser. 2, Vol. VI, 1866, pp. 67-112, Pl. XXV. (Separates, July, 1866.)

.59 Fourth Contribution to the Herpetology of Tropical America. *Proc. Acad. Nat. Sci. Phila.* Vol. XVIII, 1866, pp. 123-132.

No date acknowledged by the Academy of Natural Sciences. See "Index," p. xiii. With descriptions of the new lacertilian genus *Cachryx,* and *Colostethus* of the Ranidæ.

.60 On Some Vertebrates from the Mesozoic Red Sandstone. *Proc. Acad. Nat. Sci. Phila.* Vol. XVIII, 1866, pp. 249, 250.

No date acknowledged by the Academy. See "Index," p. xiii. Phœnixville, Pa., fossils. Description of *Mastodonsaurus durus* (=*Eupelor durus*).

.61 Remarks on the Remains of a Gigantic Extinct Dinosaur from the Cretaceous Greensand of New Jersey. *Proc. Acad. Nat. Sci. Phila.* Vol. XVIII, 1866, pp. 275-279.

No date acknowledged by the Academy. See "Index," p. xiii. Description of *Lælaps aquilunguis.*

1867.62 Remarks on the Geological Horizon of the Mesozoic Sand-
Feb. stone of Pennsylvania. *Proc. Acad. Nat. Sci. Phila.* Vol.
13 XVIII, 1866, p. 290.

*Pterodactylus longispinis* from Pa. Trias. No description.

.63 Third Contribution to the History of the Balaenidæ and
Feb. Delphinidæ. *Proc. Acad. Nat. Sci. Phila.* Vol. XVIII,
13 1866, pp. 293-300.

Remarks on eight species, five of them new.

.64 On the Reptilia and Batrachia of the Sonoran Province of
Feb. the Nearctic Region. *Proc. Acad. Nat. Sci. Phila.* Vol.
13 XVIII, 1866, pp. 300-314.

*Hyla curta* Cope. On a collection made along the Mexican border by Dr. Coues, and others. General discussion of the distribution of species in the Sonora province. Includes a synopsis of the genus *Caudisoma* (*Crotalus*).

.65 On Anatomical Peculiarities in Some Dinosauria. *Proc.*
Feb. *Acad. Nat. Sci. Phila.* Vol. XVIII, 1866, pp. 316, 317. (Title
13 in Index: On *Lelaps.*)

Relations of tibia and fibula in *Lælaps.*

.66 Fifth Contribution to the Herpetology of Tropical America.
Feb. *Proc. Acad. Nat. Sci. Phila.* Vol. XVIII, 1866, pp. 317-323.
13 New species and a new genus of snakes, *Mesopeltis,* all from Mexico.

.67 The Fossil Reptiles of New Jersey. *Amer. Nat.,* Vol. I,
March 1867, pp. 23-30.

General account of the Cretaceous reptilia.

.68 On Euclastes, a Genus of Extinct Chelonidæ. *Proc. Acad.*
June *Nat. Sci. Phila.* Vol. XIX, 1867, p. 31.
(?) No date acknowledged by the Academy. See "Index," p. xiii. Skull from Cretaceous of New Jersey. No description except length and breadth of skull

.69 On *Megaptera braziliensis*. *Proc. Acad. Nat. Sci. Phila.* Vol.
June XIX, 1867, p. 32.
(?) No date acknowledged by the Academy. See "Index," p.
xiii. Nine lines describing a young skeleton presented to the
Academy.

.70 On Euclastes, a Genus of Extinct Chelonidæ. *Proc. Acad.*
July *Nat. Sci. Phila.* Vol. XIX, 1867, pp. 39-42.
20 See 68 for original notice. Adequate description here.

.71 On the Families of the Raniform Anura. *Journ. Acad. Nat.*
Aug. *Sci. Phila.*, Ser. 2, Vol. VI, 1867, pp. 189-206. (Separates,
August, 1867.)

.72 On a Collection of Reptiles from Owen's Valley, California,
Nov. made by Dr. G. H. Horn, with Remarks on the Origin of
1 Species. *Proc. Acad. Nat. Sci. Phila.* Vol. XIX, 1867, pp.
85, 86.
Notes occurrence of *Scaphiropus holbrookii* near Schuylkill, New York. Compared the genera *Hyla, Scytopis, Osteocephalus* and *Trachycephalus,* which he considered represented a natural series measured by the relative degree of ossification of the cranium.

.73 A New Genus of Cyprinoid Fishes from Virginia. *Proc.*
Nov. *Acad. Nat. Sci. Phila.* Vol. XIX, 1867, pp. 95-97.
1 *Phenacobius teretulus* N. G. et Sp., and *P. uranops,* from
southeastern Va.

1868.74 Note on the Fossil Reptiles near Fort Wallace. Le Conte:
Feb. *Notes on the Geology of the Survey for the Extension of
the Union Pacific Railway, E. D., from the Smoky Hill
River, Kansas, to the Rio Grande.* Philadelphia, 1868, p. 68.

.75 Remarks on Four Species of Extinct Mammalia from the
May Miocene Deposits in Charles County, Maryland. *Proc. Acad.*
11 *Nat. Sci. Phila.* Vol. XIX, 1867, pp. 131, 132.
*Rhabdosteus* described.

.76 Remarks on the Cave Contents in Southwestern Virginia.
May *Proc. Acad. Nat. Sci. Phila.* Vol. XIX, 1867, pp. 137, 138.
11 Brief notice of fossils in cave, Wythe Co.

.77 An Addition to the Vertebrate Fauna of the Miocene Period,
May with a Synopsis of the Extinct Cetacea of the United States.
11 *Proc. Acad. Nat. Sci. Phila.* Vol. XIX, 1867, pp. 138-156.
Thirty-three species of Elasmobranchii and one Teleost (*Sphyræna speciosa*) determined by fossil teeth from Charles Co., Maryland. Two species of *Thecachampsa* based on isolated teeth; review of American fossil Cetacea, with descrip-

tion of several new species, types in the Philadelphia Academy collection.

.78 On the Genera of Fresh-Water Fishes *Hysilepis*, Baird, and
May *Photogenis* Cope, their Species and Distribution. *Proc. Acad.*
11. *Nat. Sci. Phila.* Vol. XIX, 1867, pp. 156-166.

New species are: *Cyrinella cercastigma; Hypsilepis coccogenis; H. galactuons, H. ardens; Phologenis telescopus, P. leucoidus, and P. scabriceps.*

.79 A Review of the Species of the *Amblystomidæ*. *Proc. Acad.*
May *Nat. Sci. Phila.* Vol. XIX, 1867, pp. 166-211.
11 With notes on the anatomy and metamorphosis.

.80 On the Habits of a Tipulideous Larva. *Proc. Acad. Nat.*
May *Sci. Phila.* Vol. XIX, 1867, pp. 222-226.
11

.81 Remarks on Extinct Reptiles which approach Birds. *Proc.*
May *Acad. Nat. Sci. Phila.* Vol. XIX, 1867, pp. 234, 235.
11 Birdlike characters in *Lælaps* and *Compsognathus.*

.82 Observations on some Vertebrata from Western Nevada and
June Northern Lower California. *Proc. Acad. Nat. Sci. Phila.*
8 Vol. XX, 1868, p. 2.

Including two new species of boas of the genus *Lichanura.*

.83 Observations on the Living Fauna of Caves in Southwestern
June Virginia. *Proc. Acad. Nat. Sci. Phila.* Vol. XX, 1868, pp.
8 85, 86.

.84 The Birds of Palestine and Panama Compared. *Amer. Nat.*
Sept. Vol. II, 1868, pp. 351-359.

.85 Remarks on a new Enalisaurian. *Proc. Acad. Nat. Sci. Phila.*
Nov. Vol. XX, 1868, pp. 92, 93.
9 *Elasmosaurus platyurus* Cope, preliminary description.

.86 An Examination of the Reptilia and Batrachia obtained by
Nov. the Orton Expedition to Ecuador and the Upper Amazon,
9 with Notes on Other Species. *Proc. Acad. Nat. Sci. Phila.*
Vol. XX, 1868, pp. 96-140.

Including new saurian genus *Opheognomon.* Synopses of the genera *Leptognathus* and *Pithecopus, Liocephalus, Celestus, Xenodon.*

.87 A New Genus of Chelonidæ, *Osteopygis,* from the New
Nov. Jersey Cretaceous Green-Sand. *Proc. Acad. Nat. Sci. Phila.*
9 Vol. XX, 1868, p. 147.

Genotype in the Academy collections.

.88 Nov. 9 On the Vertebræ of a Serpent from the Green-Sand of New Jersey. *Proc. Acad. Nat. Sci. Phila.* Vol. XX, 1868, p. 147. (Index title: On Fossil Snakes from New Jersey.)

*Palæophis littoralis,* Cope.

.89 Nov. On the Genus *Lælaps*. *Amer. Journ. Sci.,* Ser. 2, Vol. XLVI, No. 138, 1868, pp. 415-417.

.90 Dec. 2 On the Distribution of Fresh-Water Fishes in the Allegheny Region of Southwestern Virginia. *Journ. Acad. Nat. Sci. Phila.,* Ser. 2, Vol. VI, pp. 207-247. (Separates, December, 1868.)

Systematic list of the species; description of new species; and discussion of distribution due to geological and physiographical causes.

.91 Dec. (?) Synopsis of the Extinct Reptilia found in the Mesozoic and Tertiary Strata of New Jersey. *Geology of New Jersey.* George H. Cook, State Geologist, 1868, Appendix B, pp. 733-738.

.92 Dec. 2 Synopsis of the Extinct Mammalia of New Jersey. *Geology of New Jersey.* George H. Cook, State Geologist, 1868, Appendix C, pp. 739-742.

.93 Dec. 2 On the Fresh-Water Origin of Certain Deposits in West New Jersey. *Proc. Acad. Nat. Sci. Phila.* Vol. XX, 1868, pp. 157, 158.

Raritan clays.

.94 Dec. 2 On Some Remains of Extinct Cetacea from the Miocene Beds of Maryland. *Proc. Acad. Nat. Sci. Phila.* Vol. XX, 1868, pp. 159, 160.

Two new species described. *Agaphelus* (modem) N. G.

.95 Dec. 2 On New Species of Extinct Reptiles, (*Clidastes iguanavus* and *Nectoportheus validus*). *Proc. Acad. Nat. Sci. Phila.* Vol. XX, 1868, p. 181.

Isolated vertebræ from Cretaceous of New Jersey.

.96 Dec. 2 Second Contribution to the History of the Vertebrata of the Miocene Period of the United States. *Proc. Acad. Nat. Sci. Phila.* Vol. XX, 1868, pp. 184-194.

Two genera, thirteen species described, mainly from the Calvert formation, types mostly in Academy collection.

1869.97 Synopsis of the *Cyprinidæ* of Pennsylvania. *Trans. Amer. Philos. Soc.* N. S. Vol. XIII, 1869, pp. 351-399, Pls. X-XIII and twenty-two figures.

Systematic arrangement of genera and species, with considerable natural history data.

.98 Supplement on Some New Species of American and African Fishes. *Trans. Amer. Philos. Soc.* N. S. Vol. XIII, 1869, pp. 400-407.

Descriptions of various species, mostly new, from North and South America and Africa.

.99 Supplementary Synopsis of the *Esoces* of Middle North America. *Trans. Amer. Philos. Soc.* N. S. Vol. XIII, 1869, pp. 407-410.

Six species differentiated.

.100 Our Own Birds. A Familiar Natural History of the Birds of the United States, by William L. Baily. Revised and edited by E. D. Cope. J. B. Lippincott Co., Phila. 12mo. (1869), pp. v-x, 11-265. Ill.

.101 On the Reptilian Orders *Pythonomorpha* and *Streptosauria.*
Feb. *Proc. Boston Soc. Nat. Hist.* Vol. XII, 1869, pp. 250-266.

.102 On the Crocodilian Genus *Perosuchus. Proc. Acad. Nat. Sci.*
Feb. *Phila.* Vol. XX, 1868, p. 203.
6 From New Grenada (Colombia).

.103 Synopsis of the Extinct Batrachia of North America. *Proc.*
Feb. *Acad. Nat. Sci. Phila.* Vol. XX, 1868, pp. 208-221.
6 Brief descriptions of groups, with descriptions of new genera and species from Linton, Ohio, coal-measures and from Trias.

.104 On *Agaphelus,* a Genus of Toothless Cetacea. *Proc. Acad.*
Feb. *Nat. Sci. Phila.* Vol. XX, 1868, pp. 221-227.
6 Based upon part of a skeleton of a whale cast ashore in 1866 on the New Jersey coast.

.105 On Some Cretaceous Reptilia. *Proc. Acad. Nat. Sci. Phila.*
Feb. Vol. XX, 1868, pp. 233-242.
6 *Clidastes, Adocus,* additional characters of *Lælaps.*

.106 On the Origin of Genera. *Proc. Acad. Nat. Sci. Phila.* Vol.
Feb. XX, 1868, pp. 242-300.
6

.107 Sixth Contribution to the Herpetology of Tropical America.
Feb. *Proc. Acad. Nat. Sci. Phila.* Vol. XX, 1868, pp. 305-313.
6 Including the new genera *Loxopholes* (lizard) and *Lystris* (snake) from Colombia.

.108 Observations on Some Extinct Reptiles, and on a Large
Feb. Rodent, *Amblyrhiza inundata. Proc. Acad. Nat. Sci. Phila.*
6 Vol. XX, 1868, p. 313. (Index title: On Extinct Reptiles.)
*Elasmosaurus orientalis, Amblyrhiza inundata,* brief notes.

.109 Observations on Reptiles of the Old World. Art. II. *Proc.*
Feb. *Acad. Nat. Sci. Phila.* Vol. XX, 1868, pp. 316-323.
6 Including new genera *Panaspis* (lizard from Australia) and *Letheobia* (snake from Zanzibar).

.110 Note on Disease among the fossil Reptilia of New Jersey.
March *Amer. Nat.* Vol. III, No. 1, 1869, p. 55.
Quotation of a letter from Cope, which, however, does not refer to pathologic but a normal condition in mosasaur jaw.

.111 Descriptions of Some Extinct Fishes Previously Unknown.
April *Proc. Boston Soc. Nat. Hist.* Vol. XII, 1869, pp. 310-317.
Three species of fossil Teleosts and seven Elasmobranchs determined by fragments from Coastal Plain of eastern United States.

.112 The Fossil Reptiles of New Jersey. *Amer. Nat.* Vol. III,
April No. 2, 1869, pp. 84-91, Pl. 2.
Popular description and restoration of Cretaceous types.

.113 A New Salamander. *Amer. Nat.* Vol. III, No. 4, 1869, p.
June 222.
Notice of a new genus, *Thorius,* from Mexico.

.114 New Finner Whale. *Amer. Nat.* Vol. III, No. 5, 1869, pp.
July 277, 278.

.115 Remarks on a New Series of Fossils from the Limestone
July Caves in the Southern States. *Proc. Acad. Nat. Sci. Phila.*
20 Vol. XXI, 1869, p. 3.
*Stereodectes tortus* brief description; Wythe Co., Va., fauna.

.116 Remarks on *Heloderma suspectum. Proc. Acad. Nat. Sci.*
July *Phila.* Vol. XXI, 1869, p. 5. (Index title: On *Heloderma*
20 *horridum*).
Exhibition of a *Heloderma horridus* from Tehuantepec.

.117 Third Contribution to the Fauna of the Miocene Period of
July the United States. *Proc. Acad. Nat. Sci. Phila.* Vol. XXI,
20 1869, pp. 6-12.
*Tretosphys, Zarhachis, Eschrichtius,* etc., Calvert formation of Maryland and Miocene of New Jersey.

.118 On the Cetaceans of the Western Coast of North America.
July By C. M. Scammon. Edited by Prof. E. D. Cope. *Proc.*
20 *Acad. Nat. Sci. Phila.* Vol. XXI, 1869, pp. 13-63. Figs. 1-17, Pl. I.
Contains much new material written in by Cope. Part I (pp. 14-32)—Systematic Synopsis of the Species of the

Cetaceans of the West Coast of North America—is entirely his. Also contains descriptions of new species inserted by Cope.

.119 Remarks on Specimens of Extinct Animals from the Island
July of Anguilla, West Indies. *Proc. Acad. Nat. Sci. Phila.* Vol.
20 XXI, 1869, p. 92.

*Loxomylus longidens,* named, no description.

.120 A Review of the Species of *Plethodontidæ* and *Desmognathidæ*.
July *Proc. Acad. Nat. Sci. Phila.* Vol. XXI, 1869,
20 pp. 93-118.

.121 Remarks on Extinct Reptiles from New Jersey. (Hay:
July Remarks on *Holops brevispinus, Ornithotarsus immanis,* and
20 *Macrosaurus proriger.*) *Proc. Acad. Nat. Sci. Phila.* Vol.
XXI, 1869, p. 123.

*Holops* described from an incomplete cranium and *Ornithotarsus* from parts of hind leg bones, tooth from New Jersey Cretaceous; *Macrosaurus proriger* (=*Tylosaurus*) upon fragment of muzzle (? Mus. Comp. Zool.) from Kansas Cretaceous.

.122 On *Mylodon annectens* from the Post-Tertiary Rocks of
Aug. South America. *Proc. Amer. Philos. Soc.* Vol. XI, 1869,
20 pp. 15, 16.

.123 The Cretaceous Tortoises (and on Modifications of Form in
Aug. the Dinosaurian Skeleton, Indicating an Approach to the
20 Birds). *Proc. Amer. Philos. Soc.* Vol. XI, 1869, p. 16.

Brief abstract.

.124 A New Mosasauroid Reptile. *Proc. Amer. Philos. Soc.* Vol.
Aug. XI, 1869, pp. 116, 117.
20 *Clidastes propython, Polycotylus latipinnis, Ornithotarsus immanis,* brief abstracts of descriptions.

.125 On some Reptilian Remains. *Amer. Journ. Sci.* Ser. 2,
Sept. Vol. XLVIII, 1869, No. 143, p. 278.
(?)

.126 On Two New Genera of Extinct Cetacea. *Amer. Nat.* Vol.
Oct. III, No. 8, 1869, pp. 444, 445. *Canad. Nat.* Ser. 2, Vol. IV,
1869, pp. 320, 321.

Abstract of paper before Amer. Assoc. Adv. Sci. Tenable descriptions of *Anoplonassa forcipata;* notices of Anguilla fossils but no names.

1870.127 Seventh Contribution to the Herpetology of Tropical Amer-
Feb. ica. *Proc. Amer. Philos. Soc.* Vol. XI, 1869, pp. 147-169,
18 Pls. IX-XI.

Mostly from Mexico, two from the Island of St. Martins, Spanish West Indies, and with a list of species in Orton's collection from Pebas, Equador, on the Upper Amazon and in Sumichast's from Tehuantepec, Mexico. Three new genera: *Symphimus* and *Teleolapsis* (Mexican snakes), and *Stereocyclops* (raniformian from Brazil).

.128 Feb. 18 Synopsis of the Extinct Mammalia of the Cave Formations in the United States, with Observations on some Myriapoda found in and near the same, and on some Extinct Mammals of the Caves of Anguilla, W. I., and of Other Localities. *Proc. Amer. Philos. Soc.* Vol. XI, 1869, pp. 171-192, Pls. III-V.

List of species and descriptions of five new mammals and five new myriapods from Virginia. Extended descriptions of *Amblyrhiza* and *Hoxomylus* from Anguilla.

.129 Feb. 18 Second Addition to the History of the Fishes of the Cretaceous of the United States. *Proc. Amer. Philos. Soc.* Vol. XI, 1869, pp. 240-244.

Nine species of Teleosts and Elasmobranchs based on teeth and various fragments from Coastal Plain of eastern United States.

.130 March The Limbs of Ichthyosaurus and Plesiosaurus. *Amer. Nat.* Vol. IV, No. 1, 1870, p. 127.

Review of Gegenbaur's essay.

.131 April Synopsis of the Extinct Batrachia, Reptilia and Aves of North America. *Trans. Amer. Philos. Soc.* N. S. Vol. XIV, 1870, pp. 1-252, Pls. I-XIVa and Figs. 1-55. Separates April, 1870, contain only pp. 1-235, Pls. II-XII and Figs. 1-51. Note from Miss Brown's MSS.

.132 April Discovery of a Huge Whale in North Carolina. *Amer. Nat.* Vol. IV, No. 1, 1870, p. 128.

*Mesoteras kerrianus.*

.133 April 12 Remarks on the Cranium of Whales and on Certain Fossil Reptiles from the North Carolina Cretaceous. *Proc. Acad. Nat. Sci. Phila.* Vol. XXI, 1869, pp. 191, 192.

*Eschrichtus polyporus* described; *Hadrosaurus triops* and *Hypribena crassicauda,* based on vertebræ; *Polydectes biturgidus* upon a tooth. The second and third of supposed Cretaceous age "intrusive in Miocene beds."

.134 May On Some New and Little Known Myriapoda from the Southern Alleghenies. *Trans. Amer. Entomol. Soc.* III, 1870-1871, pp. 65-67. *Ann. & Mag. Nat. Hist.* Ser. 4, Vol. VI, 1870, pp. 425-427.

.135 May On *Megadactylus polyzelus* of Hitchcock. *Amer. Journ. Sci.* Ser. 2, Vol. XLIX, pp. 390-392. *Ann. & Mag. Nat. Hist.* Ser. 4, Vol. V, 1870, pp. 454, 455.

.136 July Die bis jetzt bekannten Schildkroten u. d. bei Kelheim u. Hannover neu aufgefunden altesten Arten derselben, von Dr. G. A. Maack (Review). *Amer. Journ. Sci.* Ser. 2, Vol. L, 1870, pp. 136-139.

.137 July On *Elasmosaurus platyurus,* Cope. *Amer. Journ. Sci.* Ser. 2, Vol. L, 1870, pp. 140, 141.

.138 July On the Hypothesis of Evolution, Physical and Metaphysical. *Lippincott's Mag.* Vol. VI, 1870, pp. 29-41; 173-180; 310-319.

The pages appeared in July, August and September.

.139 July 15 On Some Etheostomine Perch from Tennessee and North Carolina. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, pp. 261-270.

Twenty species described (eight new).

.140 July 15 On Some Reptilia of the Cretaceous Formation of the United States. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, pp. 271-274 and 275.

*Polydectes biturgidus, Liodon oongrops* and *L. validus,* described; *Taphrosaurus,* new genus.

.141 July 15 Molar Tooth and Fragment of Skeleton. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, p. 278.

Specimens exhibited.

.142 July 15 Verbal Communication at Meeting of the American Philosophical Society, February 18, 1870. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, p. 284.

Notice of new species of *Mosasaurus, M. oarthrus, M. fulciatus,* from the New Jersey Cretaceous.

.143 July 15 Fourth Contribution to the History of the Fauna of the Miocene and Eocene Periods of the United States. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, pp. 285-294.

Cetacea; *Sus* sp. (subsequently *S. vagrans,* Cope) and *Thinotherium* gen. nov.; fishes. Types of *S. vagrans* and *Thinotherium annulatum* in American Museum of Natural History.

.144 July 15 On Adocus, a Genus of Cretaceous Emydidæ. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, pp. 295-298.

Extended description, five species referred.

.145 July 15 Note on Skeletons Found Near Woodbury. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, pp. 310, 311.

Probably early Europeans.

.146 Photographic Pictures of Figures of the Human Foot on
July Rocks. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, p. 311.
15 Indian drawings.

.147 Fossil Fishes. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, p.
July 316.
15 Exhibit of fishes from Green River shales—2 named but not described. See also No. 154.

.148 Observations on the Fauna of the Southern Alleghanies.
Sept. *Amer. Nat.* Vol. IV, No. 7, 1870, pp. 392-402.
Fishes barely referred to.

.149 Additional Note on *Elasmosaurus platyurus*. *Amer. Journ.*
Sept. *Sci.* Ser. 2, Vol. L, 1870, pp. 268, 269.

.150 On the Structural Characteristics of the Cranium in the
Oct. Lower Vertebrata. *Amer. Nat.* Vol. IV, No. 8, 1870, pp. 505-508.
An abstract of 163.

.151 Reptiles of the Triassic Formation of the United States.
Nov. *Amer. Nat.* Vol. IV, No. 9, 1870, pp. 562, 563.
Abstract of paper before A. A. A. S. No. 166. *Belodon lepturus* named, no description.

.152 Vertebræ and other parts of a New Species of Bottosaurus.
Nov. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, p. 367.
21 Abstract four lines.

.153 A New Dycynodont cranium from the Trias of South Africa.
Nov. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, p. 370.
21 Abstract of No. 156.

.154 Observations on the Fishes of the Tertiary Shales of Green
Nov. River, Wyoming Territory. *Proc. Amer. Philos. Soc.* Vol.
21 XI, 1870, pp. 380-384.
*Asineops squamifrons* N. G. et Sp., two species of *Clupea* and one of *Cyprinodon*.

.155 Supplementary notice of a New Chimaerid from New Jer-
Nov. sey. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, p. 384.
21 *Leptomylus cookii*, Cope.

.156 *Lystrosaurus frontosus*. *Proc. Amer. Philos. Soc.* Vol. XI,
Nov. 1870, p. 419.
21 A new genus of Dicynodont reptiles from the Permian of South Africa. (Type believed to be in the collections of Yale University.)

.157 On *Astracanthus Agassiz*. *Proc. Amer. Philos. Soc.* Vol.
Nov. XI, 1870, pp. 439, 440. (5 lines).
21 First record of this genus from the United States.

.158 Nov. 21 On *Labidesthes* Cope. *Proc. Amer. Philos. Soc.*, Vol. XI, 1870, p. 440. (5 lines.)

Verbal notes.

.159 Nov. 21 On the Reptilia of the Triassic Formations of the Atlantic Region of the United States. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, pp. 444-446. *Ann. & Mag. Nat. Hist.*, Ser. 4, Vol. VI, 1870, pp. 498-500.

Discussion of affinities of various species; *Pneumatoarthrus* described.

.160 Nov. 21 Some Australian Skulls and a Maori Skull. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, p. 446.

.161 Nov. 21 A Partial Synopsis of the Fishes of the Fresh Waters of North Carolina. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, pp. 448-495, figs. 1, 2.

The first considerable report on the fresh-water fishes of N. C. 81 species are described. Included are descriptions of a considerable number of new as well as old species from sections reaching from Maine to Indiana.

.162 Nov. 21 *Liodon perlatus* and *Mosasaurus brumbyi*. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, pp. 496-497.

Abstract, seven lines.

.163 Nov. 21 On the Structure of the Crania of the Orders of Reptilia and Batrachia. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, pp. 497, 498. *Ann. & Mag. Nat. Hist.* Ser. 4, Vol. VII, 1871, pp. 67, 68.

Recent and extinct. Notes. Ichthyopterygia and Anomodontia.

1871.164 Catalogue of Batrachia and Reptilia obtained by J. A. McNiel in Nicaragua. *Second and Third Ann. Report, Trustees, Peabody Acad. Sci.* 1869-1870, pp. 80-82.

Including a new genus of snake, *Enulius*.

.165 Catalogue of Reptilia and Batrachia obtained by C. J. Maynard in Florida. *Second and Third Ann. Report, Trustees, Peabody Acad. Sci.*, 1869-1870, pp. 82-85.

.166 On the Homologies of some of the Cranial Bones of the Reptilia and on the Systematic Arrangement of the Class. *Proc. A. A. A. S.* XIX Meet. 1870, pp. 194-246, figs. 1-24.

With a catalogue of the families of the Reptilia and a note on the stratigraphic relation of the orders.

.167 Note in Reply to Dr. Seeley's Remarks on my Interpretation of the Structure of the Cranium of *Ichthyosaurus*. *Proc. A. A. A. S.* XIX Meet. 1870, pp. 246, 247.

.168 On the Fossil Reptiles and Fishes of the Cretaceous Rocks of Kansas. Preliminary Report, U. S. Geological Survey of Wyoming, etc. (Being a Second [4th] Ann. Report of Progress), 1871, pp. 385-424.

For fishes, 5 species of *Saurocephalus,* and 1 each of *Ichthyodectes, Apsopilix* and *Sphyraena,* are described, and a tooth of *Enchodus* sp., is briefly referred to.

.169 On the Fishes of the Tertiary Shales of Green River, Wyoming Territory. Preliminary Report, U. S. Geological Survey of Wyoming, etc. (Being a Second [4th] Ann. Report of Progress), 1871, pp. 425-431.

Two species of *Asineops* are described; the genus *Ermatopterus* is established and the species *E. nickseri* described; 2 genera of *Clupea* are described as is also *Osteoglossum encoastum* N. Sp.

.170 Recent Reptiles and Fishes. Report on the Reptiles and Fishes obtained by the Naturalists of the Expedition. Preliminary Report, U. S. Geological Survey of Wyoming, etc. (Being a Second [4th] Ann. Report of Progress), 1871, pp. 432-442.

Eight reptiles from Utah, Colorado and Wyoming. In fishes 1 Cottid, 2 Salmonids, 4 Catostomids, and 11 Cyprinids including 15 new species are described.

.171 Jan. New Fossil Fishes. *Amer. Nat.* Vol. IV, 1870-1871, p. 695. *Amer. Journ. Sci.* Ser. 3, Vol. I, p. 386.

Species of *Saurocephalus* Harland and *Ichyodectes* gen. nov. are described from specimens collected by Professor B. F. Mudge in the Cretaceous of Kansas. Abstract of 175.

.172 Feb. On Siredon-Metamorphoses. *Amer. Journ. Sci.* Ser. 3, Vol. I, 1871, pp. 89, 90. Reprint, *Ann. & Mag. Nat. Hist.* Ser. 4, Vol. VII, 1871, pp. 246, 247.

Reprinted by Dr. H. C. Yarrow in *Rept. U. S. Geol. Survey West of the* 100th *Meridian* (Wheeler), Vol. V, Chap. IV, pp. 517-519.

.173 Feb. 17 Some Remains of a New Cretaceous Tortoise and on *Lælaps. Proc. Amer. Philos. Soc.* Vol. XI, 1870, p. 515.

*Adocus syntheticus* described; metatarsals of *Lælaps.*

.174 Feb. 17 The Osteology of *Megaptera bellicosa. Proc. Amer. Philos. Soc.* Vol. XI, 1870, p. 516.

.175 Feb. 17 On the *Saurodontidæ. Proc. Amer. Philos. Soc.* Vol. XI, 1870, pp. 529-538. Abstract, "New Fossil Fishes," *Amer. Nat.* Vol. IV, 1870, p. 695; and *Amer. Journ. Sci.* Ser. 3, Vol. I, p. 386.

See 171 for note on new genera. Five species of *Saurocephalus* (three new) described, one *Saurodon* and *Ichthyodectes ctenodon* Sp. N. For preliminary account see No. 171.

.176 Feb. 17 On the Fishes of a Fresh Water Tertiary in Idaho, discovered by Capt. Clarence King. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, pp. 538-547.

Chiefly Cyprinid fishes of supposed Pliocene age: *Diastichus, Oligobelus, Anchybopsis, Rhabdofario,* new genera, based upon pharyngeal bones except the last.

.177 Feb. 17 On the Adocidæ. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, pp. 547-553.

Additional observations upon *Adocus* Cope, with a key to the species; *Zygoramma, Homorophus,* new genera of Adocidæ, based upon fossils from the New Jersey Cretaceous.

.178 Feb. 17 Eighth Contribution to the Herpetology of Tropical America. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, pp. 553-559.

Report upon collections of Ophidia and Batrachia from Pebas, Ecuador (Hauxwell), Brazil (Thayer Exp.), Turk's Island, W. I. (Ebell), and St. Eustatia (van Rigjersma). *Enulius* gen. nov. ophid. from Nicaragua.

.179 Feb. 17 Contribution to the Ichthyology of the Marañon. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, pp. 559-570, eight figures.

*Stethaprion, Holotaxis, Plethodectes, Odontostilbe,* new Characid genera described. Five new species of Siluridæ, and three new Chromidæ (Cichlidæ) described.

.180 Feb. 17 *Mosasaurus maximus* (and *Liodon ictericus* and *L. mudgei*). (Frazer—Note on two Species of Pythonomorpha from Kansas and New Mexico.) *Proc. Amer. Philos. Soc.* Vol. XI, 1870, pp. 571-572.

.181 Feb. 17 On some Species of Pythonomorpha from the Cretaceous Beds of Kansas and New Mexico. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, pp. 574-584. Abstract, *Amer. Nat.* Vol. VI, 1872, p. 246.

*Liodon dyspelor* from New Mexico; *L. ictericus* and *mudgei;* and *Clidastes cinerarium* from Kansas.

.182 Feb. 17 On Three Extinct Astaci from the Fresh Water Territory of Idaho. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, pp. 605-607.

Types in the Smithsonian Institution. King expedition.

.183 Feb. 17 Note on *Saurocephalus* Harlan. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, p. 608. Abstract, *Amer. Journ. Sci.* Ser. 3, Vol. I, 1871, p. 386.

Discussion of affinities.

.184 Feb. 17 Fossils from West Indian Island Caves. *Proc. Amer. Philos. Soc.* Vol. XI, 1870, p. 608. Abstract, *Amer. Journ. Sci.* Ser. 3, Vol. I, p. 385.

Notice of additional collections from Anguilla, *Loxomylus latidens* described.

.185 March On the System of the Batrachian Anura of the British Museum Catalogue. *Amer. Journ. Sci.* Ser. 3, Vol. I, 1871, pp. 198-203.

.186 March Cave Mammals in Pennsylvania. *Amer. Nat.* Vol. V, 1871, p. 58.

Abstract of 196.

.187 March 14 Remarks on a Specimen of *Trigonocephalus* and *Oxyrrhopus plumbeus*. *Proc. Acad. Nat. Sci. Phila.* Vol. XXII, 1870, p. 90.

Fer-de-lance a serious pest on the islands of Martinique and Guadaloupe, might be reduced by importation of *Oxyrrhopus* which feeds on them.

.188 March 14 Observations on Some Fishes New to American Fauna found at Newport, Rhode Island, by Samuel Powell. *Proc. Acad. Nat. Sci. Phila.* Vol. XXII, 1870, pp. 118-121.

Eleven species listed and some described, including three new species mainly West Indian stragglers brought up by the Gulf Stream.

.189 March 14 Supplementary Note on Two New Fishes from the Southern Coast. *Proc. Acad. Nat. Sci. Phila.* Vol. XXII, 1870, pp. 120, 121.

*Centropristis subligularius* and *Gobiesax strumosus* N. Sp., from Hilton Head, S. C.

.190 March 14 Note on Fishes from Atlantic City, New Jersey. *Proc. Acad. Nat. Sci. Phila.* Vol. XXII, 1870, p. 121.

*Priacanthus altus* and *Hemiramphus macrorhynchus*.

.191 March 14 Remarks on Fossil Reptiles from the Cretaceous Beds of Kansas. *Proc. Acad. Nat. Sci. Phila.* Vol. XXII, 1870, p. 132.

Tenable description of *Liodon ictericus, L. mudgei, L. dyspelor, Clidastes cinerionum* (*sic*).

.192 May 9 Observations on *Sauropleura remex* and *Osteocephalus amphiuminus*. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIII, 1871, p. 53.

.193 May 9 On Fishes from the Amazon River. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIII, 1871, p. 55.

Exhibit and remarks on four species found above the mouth of the Rio Negro.

.194 On some of the Siluroids of the Amazon. *Proc. Acad. Nat.*
July *Sci. Phila.* Vol. XXIII, 1871, p. 112.
11 Oral remarks on certain anatomical structures as a basis
for taxonomy of Silurids.

.195 On *Plectognathi* and *Lophobranchii*. *Proc. Acad. Nat. Sci.*
Aug. *Phila.* Vol. XXIII, 1871, pp. 157, 158.
15 Structure serving as basis for differentiation from other
fishes and for classification in the system.

.196 The Port Kennedy Bone Cavern. *Proc. Amer. Philos. Soc.*
Aug. Vol. XII, 1871, pp. 15, 16.
18 For abstract see 186. Preliminary notice of the fauna.
See. No. 200.

.197 Supplement to the "Synopsis of the Extinct Batrachia and
Aug. Reptilia of North America." *Proc. Amer. Philos. Soc.* Vol.
18 XII, 1871, pp. 41-52.
Descriptions of *Liodon sectorius* n. sp., *Zygoramma microglypha* n. sp., *Catapleura ponderosa* n. sp., *Bottosaurus macrorhynchus* Harlan, *Hadrosaurus cavatus* n. sp., all from the
New Jersey Cretaceous.

.198 On Two Extinct Forms of Physostomi of the Neotropical
Aug. Region. *Proc. Amer. Philos. Soc.* Vol. XII, 1871. pp. 52-55.
18 *Prymnetes* and *Anædopogon,* new genera.

.199 On the Occurrence of Fossil *Cobitidæ* in Idaho. *Proc.*
Aug. *Amer. Philos. Soc.* Vol. XII, 1871, p. 55.
18 *Diastichus* Cope referred to the Cobitidæ.

.200 Preliminary Report on the Vertebrata discovered in the
Aug. Port Kennedy Bone Cave. *Proc. Amer. Philos. Soc.* Vol.
18 XII, 1871, pp. 73-102, figs. 1-20.
Descriptions and notices of thirty-four species of mammals,
thirteen of them new, and *Praotherium,* N. Gen.

.201 On *Megaptera bellicosa*. *Proc. Amer. Philos. Soc.* Vol.
Aug. XII, 1871, pp. 103-108, figs. 21-22.
18 Description of skeleton from St. Bartholomew, W. I.

.202 Additional Note on *Balænoptera* vel *Sibbaldius sulfureus*
Aug. Cope. *Proc. Amer. Philos. Soc.* Vol. XII, 1871, p. 108.
18

.203 Remarks on Ancient Rock Inscriptions in Ohio. *Amer. Nat.*
Sept. Vol. V, 1871, p. 546.

.204 On the Extinct Tortoises of the Cretaceous of New Jersey.
Sept. *Amer. Nat.* Vol. V, 1871, pp. 562-564. (Abstract of paper
read before A. A. A. S. Exactly reprinted in *Proc. A. A.
A. S.*, XX Meet., pp. 344, 345.)

.205 Sept. Observations on the Systematic Relations of the Fishes. *Amer. Nat.* Vol. V, 1871, pp. 579-593. *Ann. & Mag. Nat. Hist.* Ser. 4, Vol. IX, 1872, pp. 155-168.

Abridged form of 211.

.206 Sept. The Laws of Organic Development. (Abstract of paper before A. A. A. S. but not printed in *Proceedings.*) *Amer. Nat.* Vol. V, 1871, pp. 593-605. *Nature,* Vol. V, 1872, pp. 252-254.

.207 Oct. 24 Ninth Contribution to the Herpetology of Tropical America. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIII, 1871, pp. 200-204.

From the Isthmus of Darien, Isthmus of Tehuantepec, eastern Ecuador, southeastern Haiti. A new snake genus, *Nothopsis* from Isthmus of Darien. Annotated synopsis of the *Teleuraspides.*

.208 Nov. Geological Expedition to Kansas. *Amer. Nat.* Vol. V, 1871, pp. 792-795.

.209 Nov. Life in the Wyandotte Cave. *Ann. & Mag. Nat. Hist.* Ser. 4, Vol. VIII, 1871, pp. 368-370. (Copied from *Indianapolis Journ.* Sept. 5, 1871.)

*Amblyopsis* sp., a blind fish found.

.210 Dec. Contribution to the Ichthyology of the Lesser Antilles. *Trans. Amer. Philos. Soc.* n. s. Vol. XIV, 1871, pp. 445-483; figs. 1-10.

Faunal list based on collection from St. Martins, St. Croix, and St. Kits. Included are numerous new species.

1872.211* Observations on the Systematic Relations of the Fishes. *Proc. A. A. A. S.* XX Meet. 1871, pp. 317-343.

For abstract see 205. Extensive presentation of Cope's views on the subject.

.212 On the Geology and Palæontology of the Cretaceous Strata of Kansas. *Preliminary Report, U. S. Geol. Survey of Montana,* etc. Being a Fifth Annual Report of Progress, Part III, pp. 318-349.

Reprinted, with slight changes, by W. E. Webb, in "Buffalo Land: An Authentic Account of the Discoveries, Adventures, and Mishaps of a Scientific and Sporting Party in the Wild West . . ." 8vo. Hubbard Bros., Philadelphia, 1872 (pp. 338-365). Extended description of vertebrate fauna of Niobrara formation, many new species.

.213 On the Vertebrate Fossils of the Wahsatch Strata. *Preliminary Report, U. S. Geol. Survey of Montana,* etc. Being a Fifth Annual Report of Progress, Part III, pp. 350-353.

Redescription of *Bathmodon, Loxolophodon* described. Compare No. 266. This report is reviewed in *Amer. Journ. Sci.* (3) III, May, 1872, and must therefore have been published in May or earlier.

.214 Report on the Recent Reptiles and Fishes of the Survey, collected by Campbell Carrington and C. M. Dawes. *Preliminary Report, U. S. Geol. Survey of Montana,* etc. Being a Fifth Annual Report of Progress, Part IV, pp. 467-476.

Twenty species described, 15 being new.

.215 Sketch of the Zoology of Pennsylvania. *Walling and Gray's Topographical Atlas of Pennsylvania,* pp. 19-22.

.216 Jan. Carboniferous Reptiles of Ohio. *Amer. Nat.* Vol. VI, 1872, p. 46.

Abstract of 220.

.217 Jan. 16 On the Fishes of the Ambyiacu River. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIII, 1871, pp. 250-294, Pls. III-XVII.

Comprises an extensive collection from Pebas, referable to 50 genera and 76 species, mostly Chromids (Cichlids), Characins, and Silurids. Nine genera and 47 species are new to science with one exception belonging to the above.

.218 Feb. 2 Note on some Cretaceous Vertebrata in the State Agricultural College of Kansas, U. S. A. *Proc. Amer. Philos. Soc.* Vol. XII, 1871, pp. 168-170.

*Anogmius* gen. nov. and *Liodon latispinis* sp. nov. described.

.219 Feb. 2 Sketch of an Expedition in the Valley of the Smoky Hill River in Kansas. *Proc. Amer. Philos. Soc.* Vol. XII, 1871, pp. 174-176.

.220 Feb. 2 Observations on the Extinct Batrachian Fauna of the Carboniferous of Linton, Ohio. *Proc. Amer. Philos. Soc.* Vol. XII, 1871, p. 177.

List of genera with brief diagnosis of characters. *Tuditanus, Cocytinus, Phlegcthontia* are new. For abstract see 216.

.221 Feb. 2 Remarks on Hyrtl's Collection. *Proc. Amer. Philos. Soc.* Vol. XII, 1871, p. 191.

.222 Feb. 2 Observations on the Distribution of certain Extinct Vertebrata in North Carolina. *Proc. Amer. Philos. Soc.* Vol. XII, 1871, pp. 210-216, Pls. I-IV.

Chiefly Triassic and Cretaceous fossils. *Hypsibema* gen. nov. and *Hadrosaurus tripos* sp. nov. are based upon skeleton fragments of Trachodont dinosaurs.

.223 Feb. 2 The Method of Creation of Organic Forms. *Proc. Amer. Philos. Soc.* Vol. XII, 1871, pp. 229-263.

.224 Feb. 13 On a Species of Galeodes. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIII, 1871, p. 295.

.225 Feb. 13 On the Fauna of the Wyandotte Cave in Southern Indiana. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIII, 1871, p. 297.
*Amblyopsis spelaeus,* the only fish found.

.226 Feb. 13 On some Fossil Reptiles from the Cretaceous Chalk of Western Kansas. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIII, 1871, pp. 297, 298.
Preliminary notice, names but no adequate descriptions of four new species of Mosasaurs.

.227 Feb. 13 On a peculiar Habit in *Phrynosoma.* *Proc. Acad. Nat. Sci. Phila.* Vol. XXIII, 1871, p. 305.
*P. ornatissima* Grd. Squirting blood from the eyes.

.228 March 7 The Survival of the Fittest. *Nature,* Vol. V, 1872, p. 363.

.229 April On a New Fossil Reptile from the Cretaceous Strata of Kansas. *Amer. Nat.* Vol. VI, 1872, p. 247.
Abstract of 263.

.230 April Families of Fossil Fishes of the Cretaceous of Kansas. *Amer. Nat.* Vol. VI, 1872, pp. 249, 250.
Abstract of 265.

.231 April On *Protostega.* *Amer. Nat.* Vol. VI, 1872, p. 251.
Abstract of 268.

.232 April On Two New Species of *Ornithosaurians* from the Kansas Cretaceous. *Amer. Nat.* Vol. VI, 1872, p. 251.
Abstract of 267.

.233 April Remarks on Mr. Price's "Phases of Modern Philosophy" (Abstract). *Amer. Nat.* Vol. VI, 1872, pp. 251, 252.
Abstract of 264.

.234 April Description of the Common Lizard of Socorro. *Proc. Boston Soc. Nat. Hist.* Vol. XIV, 1871, p. 303.
*Uta auriculata.*

.235 April 16 On *Megaptera bellicosa.* *Proc. Acad. Nat. Sci. Phila.* Vol. XXIV, 1872, p. 11.

.236 April 16 On *Holops pneumaticus.* *Proc. Acad. Nat. Sci. Phila.* Vol. XXIV, 1872, pp. 11, 12.

.237 April 16 List of the Reptilia of the Eocene Formations of New Jersey. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIV, 1872, pp. 14-18.

Two new species of Chelonia described and one new crocodilian.

.238 May–Sept. Evolution and its Consequences. *Penn Monthly* Vol. III, 1872, pp. 222-236; 366-385; 429-439; 461-476.

The instalments appeared in May, July, August and September, respectively.

.239 May Curious Habit of a Snake. *Amer. Nat.* Vol. VI, 1872, p. 309. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIV, 1872, p. 40.

*Oryclophis æstivus* from North Carolina.

.240 June 8 Remarks on Discoveries recently made by Prof. O. C. Marsh. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIV, 1872, pp. 140, 141.

Separates, June 8, 1872. Date taken from Miss Brown's MSS. Critical review of Marsh's contributions on Mosasaurs.

.241 June 25 Synopsis of the Species of the Chelydrinæ. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIV, 1872, pp. 22-29.

.242 June 25 On an Extinct Whale from California. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIV, 1872, pp. 29, 30.

*Eschrichtius davidsonii.*

.243 June 25 On *Bathmodon radians*. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIV, 1872, p. 38.

Preliminary description.

.244 June 25 Intelligence in Monkeys. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIV, 1872, pp. 40, 41. Abstract, *Amer. Nat.* Vol. VI, 1872, pp. 371, 372.

.245 July Report on the Wyandotte Cave and its Fauna. *Amer. Nat.* Vol. VI, 1872, pp. 406-422, figs. 109-116. *Third and Fourth Ann. Rept. Geol. Survey Indiana,* 1871-1872, pp. 157-182, figs. 109-116. *Nature,* Vol. VII, 1872, pp. 11-14, figs. 1-8. Abstract, "Observations on Wyandotte Cave and its Fauna," *Eighth, Ninth and Tenth Ann. Rept. Geol. Survey Indiana,* 1876-77-78, pp. 489-506, figs. 109-116.

Includes descriptions of species from the Mammoth Cave. *Ambylopsis spelaeus* the only fish.

.246 July The Anæsthetic School. *Amer. Nat.* Vol. VI, 1872, pp. 431, 432.

Abstract of 259.

.247 A New Genus of Ungulates. *Amer. Nat.* Vol. VI, 1872,
July p. 438.
Abstract of 266.

.248 Food of *Plesiosaurus.* *Amer. Nat.* Vol. VI, 1872, p. 439.
July Abstract of 260.

.249 On a new Genus of *Pleurodira* from the Eocene of Wyo-
July ming. *Proc. Amer. Philos. Soc.* Vol. XII, 1872, pp. 472-477.
11 *Notomorpha* gen. nov., 3 species, and *"Notharctus" vasacciensis* (=*Eohippus*). For date see *Pal. Bull.,* No. 12, p. 3.

.250 Descriptions of Some New Vertebrata from the Bridger
July Group of the Eocene. *Proc. Amer. Philos. Soc.* Vol. XII,
29 1872, pp. 460-465. *Pal. Bull.* No. 1, pp. 1-6.

This bulletin includes first descriptions of *Mesonyx* and several new *Chelonia.*

This is the first of a series of notices describing new genera and species of fossil vertebrates discovered by Professor Cope or his assistants during his expeditions for the Hayden Survey in 1872 and 1873. The descriptions were written in the field and forwarded by mail (in two instances by telegraph) to Philadelphia for immediate publication. They are in large part transcripts from his field notebooks which are preserved in the files of the American Museum.

Their purpose was in part to anticipate the work of Professor Marsh, who was known to be studying fossil faunas of the same regions, and between whom and Cope there was a growing rivalry. They precipitated a bitter controversy, turning mainly on the correctness of the stated dates of publication. Professor Cope, in reply to Marsh's claim that the papers were seriously antedated published sworn statements from the printers that the papers were printed and delivered as dated, and somewhat less conclusive evidence as to the distribution of the separata to scientific institutions or individuals within a few days of the stated dates.

Although Professor Marsh failed to retract his charges, it is clear from this evidence, coupled with the internal evidence afforded by close study of the papers, comparison with field notebooks and other considerations that the bulletins were printed and, in most cases if not all, some copies were distributed approximately at the printed dates of publication. Any intentional antedating is out of the question. Under the circumstances it appears wholly proper to accept the accuracy of the dating.

W. D. M.

.251 Aug. The Life of the Plains. *Southern Mag.* N. S. Vol. IV, 1872, pp. 146-155.

.252 Aug. 3 Second Account of New Vertebrata from the Bridger Eocene. *Proc. Amer. Philos. Soc.* Vol. XII, 1872, pp. 466-468. *Pal. Bull.* No. 2, pp. 1-3.

First descriptions of *Helotherium* (=*Orohippus* Marsh of identical date), *Stypolophus* (=*Sinopa* Leidy), *Pantolestes, Pseudotomus* (here referred to Edentata but in fact a rodent allied to *Paramys* Leidy) *Hadrianus* (earliest land tortoise).

.253 Aug. 7 Third Account of New Vertebrata from the Bridger Eocene of Wyoming Territory. *Proc. Amer. Philos. Soc.* Vol. XII, 1872, pp. 469-472. As "Third Account of New Vertebrata from the Bridger Eocene of Wyoming Valley," *Pal. Bull.* No. 3, pp. 1-4.

First descriptions of *Miacis, Tomitherium* (=*Northarctus* Leidy), etc.

.254 Aug. 12 On the Existence of Dinosauria in the Transition Beds of Wyoming. *Proc. Amer. Philos. Soc.* Vol. XII, 1872, pp. 481-483. *Pal. Bull.* No. 4, pp 1, 2.

First description of *Agathaumas.*

.255 Aug. 19 Telegram Describing Extinct Proboscidians found in Wyoming. *Pal. Bull.* No. 5.

*"Lefalophodon,"* (intended for *Loxolophodon*) with three species, also badly misspelled. The telegram was evidently sent upon discovery of the fine skull which is the type of *Eobasileus cornutus* by Professor Cope at Haystack Mountain in the Washakie basin. It is the first published announcement of his Dinocerata discoveries, but they are here *referred to* the genus *Loxolophodon* based upon a Coryphodont from the Lower Eocene. With conjectural corrections of specific names. See 286.

.256 Aug. 20 Notices of New Vertebrata from the Upper Waters of Bitter Creek, Wyoming Territory. *Proc. Amer. Philos. Soc.* Vol. XII, 1872, pp. 483-486. *Pal. Bull.* No. 6, pp. 1-4. Abstract, "The Proboscidians of the American Eocene" *Amer. Nat.* Vol. VI, 1872, pp. 773, 774.

First description of *Synoplotherium* and *Eobasileus.* The relationship of the former to *Mesonyx* was not yet recognized; it was thought to be allied to *Anchippodus (Tillodontia),* the enlarged canine being mistaken for an incisor.

The new genus *Eobasileus* is here based upon the species *cornutus* with a number of fragmentary specimens as types, not including the fine skull which is the type in the telegram from Black Buttes, written later than this notice but published earlier (see No. 255). Errors of transmission in the telegram being corrected, and the stated dates of publication being accepted, the type specimen of *cornutus* is the complete skull and the monotypic genus *Eobasileus* rests upon this species. It may be remarked incidentally that neither the original type of *Tinoceras* Marsh nor the skull subsequently used by him as a neotype of the genus is congeneric with *Eobasileus*.

.257 Aug. 22 Second Notice of Extinct Vertebrates from Bitter Creek, Wyoming. *Proc. Amer. Philos. Soc.* Vol. XII, 1872, pp. 487, 488. *Pal. Bull.* No. 7, pp. 1, 2.

Chiefly an extended account of the discoveries noticed in the telegram from Black Buttes, published a few days earlier.

.258 Sept. 3 On the Horns of *Cariacus virginianus*. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIV, 1872, p. 124.

.259 Sept. 3 On different Schools of Naturalists. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIV, 1872, pp. 124, 125.

See 246 for abstract.

.260 Sept. 3 Description of *Plesiosaurus gulo* and the Turtle afterwards named *Toxochelys latiremis*. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIV, 1872, pp. 127-129.

See 248 for abstract.

.261 Sept. 3 Remarks on *Mastodon* from New Mexico. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIV, 1872, p. 142.

.262 Sept. 30 Catalogue of the Pythonomorpha found in the Cretaceous Strata of Kansas. *Proc. Amer. Philos. Soc.* Vol. XII, 1871, pp. 264-287.

Descriptions of several characteristic species of Mosasaurs from the Kansas chalk: *Edestosaurus* (=*Clidastes*) *tortor* and *stenops*, *Holcodus* (=*Platecarpus*) *coryphaeus*, *Liodon* (=*Tylosaurus*) *proriger* and *dyspelor*, etc. The first page only appeared in the previous number of the Proc.

.263 Sept. 30 On a New Testudinate from the Chalk of Kansas. *Proc. Amer. Philos. Soc.* Vol. XII, 1872, pp. 308-310.

Description of *Cynocercus incisus* gen. et sp. nov. (based on caudal vertebræ, ? *Toxochelys*) and of *Hyposaurus vebbii*, crocodilian, the latter from the Benton shales. For abstract, see 229.

.264 Sept. 30 Remarks on Mr. Price's "Phases of Modern Philosophy." *Proc. Amer. Philos. Soc.* Vol. XII, 1872, pp. 316-320.

For abstract, see 233.

.265 Sept. 30 On the Families of Fishes of the Cretaceous Formation of Kansas. *Proc. Amer Philos. Soc.* Vol. XII, 1872, pp. 327-357.

Revision of the genera and species with descriptions of sixteen species. For abstract, see 230.

.266 Sept. 30 On *Bathmodon,* an Extinct Genus of Ungulates. *Proc. Amer. Philos. Soc.* Vol. XII, 1872, pp. 417-420.

First description of *Coryphodon* remains from the Evanston (Wyoming) Wasatch. Referred here to the Perissodactyla. The material studied included upper teeth and various fragments of the skeleton, but no lower molars, and the affinity to the European genus *Coryphodon* Owen, then known chiefly from the lower teeth, was naturally not recognized. The name *Loxolophodon,* subsequently used for a genus of *Unitatheriidæ,* was here first proposed tentatively for *B. semicinctus,* a second species of *Bathmodon,* in case it should prove generically distinct. For abstract, see 247. The paper was read Feb. 16, 1872. In case the date of publication is really as late as September the genera *Bathmodon* and *Loxolophodon* will date from No. 213.

.267 Sept. 30 On Two New Ornithosaurians from Kansas. *Proc. Amer. Philos. Soc.* Vol. XII, 1872, pp. 420-422.

The Kansas pterodactyles are recognized as belonging to the genus *Ornithocheirus* Seeley, typically from the English chalk and greensand. Two new species *O. umbrosus* and *harpyia* described. For abstract, see 232.

.268 Sept. 30 A Description of the Genus *Protostega,* a form of Extinct Testudinata. *Proc. Amer. Philos. Soc.* Vol. XII, 1872, pp. 422-433.

First description of the gigantic marine Cretaceous turtle *Protostega* based on remains from the Kansas chalk now in the American Museum collections. *Atlantochelys* and *Pneumatarthus* referred to the same group. For abstract, see 231.

.269 Oct. The Peculiar Coloration of Fishes. *Amer. Nat.* Vol. VI, 1872, p. 637.

Color changes due to contraction and expansion of chromatophores.

.270 Oct. 12 On a New Vertebrate Genus from the northern part of the Tertiary Basin of Green River. *Proc. Amer. Philos. Soc.* Vol. XII, 1872, p. 554. *Pal. Bull.* No. 8, p. 1.

*Anaptomorphus aemulus.* First record of a recognized primate from the North American Eocene.

.271 Oct. 12 Descriptions of New Extinct Reptiles from the Upper Green River Eocene Basin, Wyoming. *Proc. Amer. Philos. Soc.* Vol. XII, 1872, pp. 554, 555. *Pal. Bull.* No. 9, p. 1.

Three new species described: *Crocodilus subulatus* and *sulciferus, Anostira radulina.*

.272 Nov. The Geological Age of the Coal of Wyoming. (Read before A. A. A. S.) *Amer. Nat.* Vol. VI, 1872, pp. 669-671.

.273 Nov. Absence of Eyes in Classification. *Amer. Nat.* Vol. VI, 1872, pp. 691, 692.

.274 Nov. The Eocene Genus *Synoplotherium.* (Read before A. A. A. S.) *Amer. Nat.* Vol. VI, 1872, p. 695.

.275 Dec. The Armed Metalophodon. *Amer. Nat.* Vol. VI, 1872, pp. 774, 775.

Abstract of 285.

.276 Dec. The Fish Beds of Osino, Nevada. *Amer. Nat.* Vol. VI, December 1872, p. 775.

Abstract of 284.

.277 Dec. 19 On the Geology of Wyoming. *Proc. Acad. Nat. Sci. Phila.* Vol. XXIV, 1872, pp. 279, 280. *Pal. Bull.* No. 10, pp. 1, 2.

1873.278 On the Extinct Vertebrata of the Eocene of Wyoming observed by the Expedition of 1872, with notes on the Geology. *Sixth Ann. Report, U. S. Geol. Survey of the Territories embracing . . . Montana,* etc. (Hayden) pp. 545-649, Pls. I-VI.

.279 Sketch of the Zoology of Ohio. *Walling and Gray's New Topographical Atlas of Ohio,* pp. 25-27.

.280 Sketch of the Zoology of Maryland. *Walling and Gray's New Topographical Atlas of Maryland,* pp. 16-18.

.281 Jan. Proboscidians of the American Eocene. Correction. *Amer. Nat.* Vol. VII, 1873, p. 49.

Correction regarding the teeth of *Eobasileus cornutus*—Hay.

.282 Jan. 31 On Two New Perissodactyles from the Bridger Eocene. *Pal. Bull.* No. 11, pp. 1, 2.

Two species of *Palacosyopinæ.* An extended form of an article of the same title appearing in *Proc. Amer. Philos. Soc.* Vol. XIII, pp. 35, 36.

.283 The Slaughter of the Buffalo. *Amer. Nat.* Vol. VII, 1873,
Feb. pp. 113, 114.

.284 On the Tertiary Coal and Fossils of Osino, Nevada. *Proc.*
Feb. *Amer. Philos. Soc.* Vol. XII, 1872, pp. 478-481.
7 For abstract, see 276. *Trichophanes hians* and *Amyzon mentoli* new genera and species.

.285 On the Dentition of *Metalophodon*. *Proc. Amer. Philos.*
Feb. *Soc.* Vol. XII, 1872, pp. 542-545.
7 For abstract, see 275. Description of *Metalophodon armatus* and *Alligator heterodon* from Black Buttes Eocene.

.286 Notice of Proboscidians from the Eocene of Southern Wyo-
Feb. ming. *Proc. Amer. Philos. Soc.* Vol. XII, 1872, p. 580.
7 Followed by note of the secretary correcting errors in the original which was issued as Pal. Bull. No. 5 (See, 1872 .255). Corrected version of telegram describing *Loxolophodon*.

.287 On an Extinct Genus of Saurodont Fishes from the Nio-
Feb. brara Cretaceous of Kansas. *Proc. Acad. Nat. Sci. Phila.*
11 Vol. XXIV, 1872, pp. 280, 281.
*Erisichthe* close to *Ichthyodectes* and *Portheus*.

.288 Note on the Cretaceous of Wyoming. *Amer. Journ. Sci.*
March Ser. 3, Vol. V, 1873, pp. 230, 231.
Slip from the "Proc. Philos. Soc., Philadelphia," published on Feb. 7. Followed by remarks by "Eds." The original not found in the Proc. Amer. Philos. Soc.—Hay.

.289 The Gigantic Mammals of the Genus *Eobasileus*. *Amer.*
March *Nat.* Vol. VII, 1873, pp. 157-160. Read before A. A. A. S.

.290 The Spike-horned Muledeer. *Amer. Nat.* Vol. VII, 1873,
March pp. 169, 170.

.291 The *Eobasileus* again. *Amer. Nat.* Vol. VII, 1873, p. 180.
March

.292 On *Toxochelys latiremis*. *Proc. Acad. Nat. Sci. Phila.* Vol.
March XXV, 1873, p. 10.
4 No description.

.293 On the Structure and Systematic Position of the Genus
March *Eobasileus* Cope. *Proc. Acad. Nat. Sci. Phila.* Vol. XXV,
4 1873, pp. 10-12.
Discussion of ordinal characters and relationships of Proboscidea.

.294 March 8 On some Eocene Mammals obtained by Hayden's Geological Survey of 1872. *Pal. Bull.* No. 12, pp. 1-6.

Partial annotated list of species from the Bridger Basin with description of *Oligstomus* gen. nov. and five new species of mammalia. Issued privately March 8, not reprinted—Hay.

.295 March 13 Dawson on Evolution. *Independent* Vol. XXV, 1873, p. 328.

.296 March 14 On the Short Footed Ungulata of the Eocene of Wyoming. *Proc. Amer. Philos. Soc.* Vol. XIII, 1873, pp. 38-74, Pls. 1-4. Extract, Journ. de Zoologie, Vol. II, 1873, pp. 168-184, Pl. VII, followed by remarks by Paul Gervais (Hay).

Revision of the Uintatheriidæ and Coryphodontidæ. Dates of earlier notices descriptive of Eocene vertebrata. Separate March 14, 1873. Date taken from Miss Brown's MSS.

.297 March 25 On *Eobasiliidæ* and *Bathmodontidæ*. *Proc. Acad. Nat. Sci. Phila.* Vol. XXV, 1873, pp. 102, 103.

Key to genera.

.298 April A New Theory of the Origin of Species (Review). *Amer. Nat.* Vol. VII, 1873, pp. 231, 232.

.299 April On some of Prof. Marsh's Criticisms. *Amer. Nat.* Vol. VII, 1873, pp. 290-299, Pls. 4, 5.

For extended form, see 306.

.300 April 10 Aztec Design. *Independent* Vol. XXV, 1873, p. 454.

.301 April 29 On a Skull of *Sus scropha*. *Proc. Acad. Nat. Sci. Phila.* Vol. XXV, 1873, p. 207.

Supposed fossil from North Carolina.

.302 April 29 On an Anourous Batrachian from the Eocene of Wyoming. *Proc. Acad. Nat. Sci. Phila.* Vol. XXV, 1873, p. 207. From Green River shale. Notice.

No name or description.

.303 May On the Tusk of *Loxolophodon cornutus*. *Amer. Nat.* Vol. VII, 1873, p. 315.

.304 May 6 On the Primitive Types of the Orders of Mammalia *Educabilia*. Read before the Amer. Philos. Soc., April 18, 1873, printed and then withdrawn on June 20, 1873. A few separates still in existence. Separate May 6, 1873.

Discussion of the broader affinities of the Eocene mammals, especially those recently discovered in the Bridger Basin.

.305 Memory and Reminiscence in Animals. *Independent* Vol.
June XXV, 1873, p. 710.
5

.306 On some of Prof. Marsh's Criticisms. *Pal. Bull.* No. 13, pp.
July 1-8.
A slightly extended form of 299.

.307 On Prof. Marsh's Criticism. *Amer. Nat.* Appendix to July
July p. i (8 lines only.)

.308 Extinct Turtles from the Eocene Strata of Wyoming. *Proc.*
July *Acad. Nat. Sci. Phila.* Vol. XXV, 1873, pp. 277-279.
8 *Trionyx heteroglyptus* and *Plastomenus thomasi* from
Bridger formation.

.309 Palaeontological Bulletin—Preliminary. 2 pp. (Gives titles
July and dates of Palaeontological Bulletins 1-13.)
16

.310 A Contribution to the Ichthyology of Alaska. *Proc. Amer.*
July *Philos. Soc.* Vol. XIII, 1873, pp. 24-32.
24 Fourteen species described, eleven new.

.311 On the Flat-Clawed Carnivora of the Eocene of Wyoming.
July *Proc. Amer. Philos. Soc.* Vol. XIII, 1873, pp. 198-209.
24 Description of *Mesonyx* and *Synoplotherium* and discussion of their affinities.

.312 On the Osteology of the Extinct Tapiroid *Hyrachyus*. *Proc.*
July *Amer. Philos. Soc.* Vol. XIII, 1873, pp. 212-224.
24 Description of the complete skelton of *Hyrachyus* found
by Professor Cope in the Bridger Basin in 1872.

.313 On some New Extinct Mammalia from the Tertiary of the
July Plains. *Pal. Bull.* No. 14, pp. 1, 2.
25 First bulletin descriptive of discoveries made by Professor
Cope in the Tertiary (Oligocene and Miocene) of northeastern Colorado in 1873. Like the preceding series these were apparently sent in from the field and are in considerable part transcripts from his field notebooks. Describes *Aelurodon* (=*Martes*) *mustelinus* and *Aceratherium* (=*Aphelops*) *megalodus*, both from the Miocene (Pawnee Creek beds) near Pawnee Buttes.

.314 On a Habit of a Species of *Blarina*. *Amer. Nat.* Vol. VII,
Aug. 1873, pp. 490, 491.

.315 The Monster of Mammoth Buttes. *Penn Monthly,* Vol. IV,
Aug. 1873, pp. 521-534, Plate.

.316 Aug. 20 Second Notice of Extinct Vertebrata from the Tertiary of the Plains. *Pal. Bull.* No. 15, pp. 1-6.

Describes various Oligocene (White River) fossils from northeastern Colorado. *Colotaxis* gen. nov. (=*Ischyromys*), *Symborodon* and *Miobasileus* Titanotheriidæ, *Peltosaurus* and four species of *Testudo*.

.317 Aug. 20 Third Notice of Extinct Vertebrata from the Tertiary of the Plains. *Pal. Bull.* No. 16, pp. 1-8.

Describes Oligocene (White River) mammals, chiefly Insectivora and Rodents. Nine new genera.

.318 Sept. 30 On Two New Species of Saurodontidæ. *Proc. Acad. Nat. Sci. Phila.* Vol. XXV, 1873, pp. 337-339.

*Portheus lestrio* and *P. gladius* described and *Daptinus* N. Gen. established.

.319 Sept. 30 On some New Batrachia and Fishes from the Coal Measures of Linton, Ohio. *Proc. Acad. Nat. Sci. Phila.* Vol. XXV, 1873, pp. 340-343.

Three species of *Conchiopsis* and one of *Peplorhina*.

.320 Oct. 16 Synopsis of New Vertebrata from the Tertiary of Colorado obtained during the summer of 1873. Pp. 1-19. Govt. Printing Office.

On the title page this paper is said to be extracted from the Seventh Annual Report of the U. S. Geological Survey of the Territories, but it does not appear in that volume.—Hay.

.321 Oct. 25 Fourth Notice of Extinct Vertebrata from the Bridger and the Green River Tertiary. *Pal. Bull.* No. 17, pp. 1-4.

*Achænodon* and *Phenacodus,* new genera.

.322 Oct. 30 Some remarkable and gigantic Animals. *Independent* Vol. XXV, 1873, p. 1351.

Unsigned. Cited by Frazer.

1874.323 Report on the Vertebrate Palaeontology of Colorado. *Seventh Ann. Report, U. S. Geol. and Geogr. Survey of the Territories* (embracing Colorado), pp. 427-533, Pls. I-VIII. Abstract, *Journ. de Zoologie* Vol. IV, 1875, pp. 354-359.

One species described; *Rhineastis, Amyzon, Clupea.*

.324 Notes on the Eocene and Pliocene Lacustrine Formations of New Mexico, including Descriptions of certain New Species of Vertebrates. *Ann. Report of the Chief of Engineers for* 1874 Vol. II, Pt. II, Appendix $\mathrm{FF}_2$ of Appendix FF, pp. 115-130.

For the original title and first date of issue see 358.

.325 On some Extinct Types of Horned Perissodactyles. *Proc. A. A. A. S.* XXII Meeting, 1873, pp. 108, 109. *Canadian Naturalist* Vol. VII, pp. 169-171. *Ann. & Mag. Nat. Hist.* Ser. 4, Vol. XIII, 1874, pp. 405, 406.

.326 The Doctrine of the Inner Light. *The Journal* (Published for Ye Society of Friends), 1874, pp. 1-7.

.327 Jan. 13 On Stone Circles in the Rocky Mountains. *Proc. Acad. Nat. Sci. Phila.* Vol. XXV, 1873, p. 370.

.328 Jan. 13 On the Types of Molar Teeth. *Proc. Acad. Nat. Sci. Phila.* Vol. XXV, 1873, p. 371.

Outline of No. 335.

.329 Jan. 21 Report on the Stratigraphy and Pliocene Vertebrate Palaeontology of Northern Colorado. *Bull. U. S. Geol. and Geogr. Survey of the Territories,* Ser. 1, No. 1, pp. 9-22.

.330 Jan. 21 Supplementary additions to the "Synopsis of New Vertebrata from the Tertiary of Colorado, 1873." *Bull. U. S. Geol. and Geogr. Survey of the Territories,* Ser. I, No. 1, pp. 22-28.

.331 Feb. Monkeys in the American Miocene. *Amer. Nat.* Vol. VIII, 1874, pp. 125, 126.

*Menotherium lemurinum;* no description. Skeleton of *Protohippus sejunctus.*

.332 Feb. The Succession of Life in North America. *Penn Monthly* Vol. V, 1874, pp. 138-145. Reprint, *Ann. & Mag. Nat. Hist.* Ser. 4, Vol. XIII, 1874, pp. 326-331.

.333 Feb. 17 On Fishes from the Coal Measures of Linton, Ohio. *Proc. Acad. Nat. Sci. Phila.* Vol. XXV, 1873, pp. 417-419.

*Conchiopsis* and *Peplorhina* are fishes not amphibians or reptiles as thought by Newberry.

.334 Feb. 17 On Fossils from the Miocene Formations of Colorado. *Proc. Acad. Nat. Sci. Phila.* Vol. XXV, 1873, pp. 419, 420.

*Menotherium lemurinum* a primate. Notice of other species from Pawnee Buttes. No adequate description.

.335 March 30 On the Homologies and Origin of the Types of Molar Teeth of Mammalia *Educabilia. Journ. Acad. Nat. Sci. Phila.* Ser. 2, Vol. VIII, 1874, pp. 71-89, figs. 1-29.

Abstract, No. 328. Separates March 30, 1874.

.336 April 9 Review of the Vertebrata of the Cretaceous Period found West of Mississippi River. Section I—On the Mutual Relations of the Cretaceous and Tertiary Formations of the West.

Section II—List of Species of Vertebrata from the Cretaceous Formations of the West. *Bull. U. S. Geol. and Geogr. Survey of the Territories,* Ser. I, No. 2, pp. 5-48.

.337 April 9 Supplementary Notices of Fishes from the Freshwater Tertiaries of the Rocky Mountains. *Bull. U. S. Geol. and Geogr. Survey of the Territories,* Ser. I, No. 2, pp. 49-51.

*Rhineastis pectinatus, Amyzon commune* and *Clupea theta* new species.

.338 April 13 On the *Plagopterinæ* and the Ichthyology of Utah. *Proc. Amer. Philos. Soc.* Vol. XIV, 1874, pp. 129-139.

Reprint April 13, 1874—date from Miss Brown's MSS. *Plagopterus, Meda,* and *Lipomeda,* new fossil genera with 3 species. Twelve freshwater fishes (5 new species) from Lake Utah. Eight species (5 new) from streams in Utah and Arizona.

.339 April 13 On the Zoology of a Temporary Pool on the Plains of Colorado. *Proc. Amer. Philos. Soc.* Vol. XIV, 1874, pp. 139, 140.

Reprints April 13, 1874—date from Miss Brown's MSS.

.340 April 28 On the Extinct Fauna of Colorado. *Proc. Acad. Nat. Sci. Phila.* Vol. XXVI, 1874, pp. 10, 11.

Discussion by Cope, LeConte and Frazer on age of "lignite" beds of N. E. Colorado.

.341 April 28 On the Age of the Lignites of the West. (Observations on the age of lignite and other formations of the West—Hay). *Proc. Acad. Nat. Sci. Phila.* Vol. XXVI, 1874, pp. 10-13.

.342 May Beale on Protoplasm (Review of *Protoplasm, or Matter and Life* by Dr. Lionel Beale). *Penn Monthly* Vol. V, 1874, pp. 377-388.

.343 May 19 Description of some Species of Reptiles obtained by Dr. John F. Bransford, Assistant Surgeon United States Navy, while attached to the Nicaraguan Surveying Expedition in 1873. *Proc. Acad. Nat. Sci. Phila.* Vol. XXVI, 1874, pp. 64-72.

.344 July A New Type of Snake. *Amer. Nat.* Vol. VIII, 1874, p. 432.

*Genhosteus prosopis* from Peru.

.345 July A Horned *Elotherium. Amer. Nat.* Vol. VIII, 1874, p. 437.

*E. ramosum* "horns" on lower jaw.

.346 Aug. 18 On a young *Balæna cisarctica. Proc. Acad. Nat. Sci. Phila.* Vol. XXVI, 1874, p. 89.

.347 Aug. 18 On the Extinct Mammalia of Colorado. (Remarks on *Symborodon, Titanotherium,* and *Eobasileus.*—Hay). *Proc. Acad. Nat. Sci. Phila.* Vol. XXVI, 1874, pp. 89, 90.

Notice of exhibition of *Symborodon crania.*

.348 Aug. 18 On the Pelvis of *Hadrosaurus. Proc. Acad. Nat. Sci. Phila.* Vol. XXVI, 1874, p. 91.

Critical comment on views of Hawkins and Leidy. Three lines.

.349 Aug. 18 On the Genus *Ctenodus. Proc. Acad. Nat. Sci. Phila.* Vol. XXVI, 1874, pp. 91, 92.

Description of bones of head—no species assigned.

.350 Sept. 29 Remarks on Viviparous Snakes of the Genus *Storeria* B. & G. *Proc. Acad. Nat. Sci. Phila.* Vol. XXVI, 1874, p. 116.

First notice of the genus as viviparous.

.351 Sept. 29 On the Age of the Bridger Eocene. *Proc. Acad. Nat. Sci. Phila.* Vol. XXVI, 1874, p. 116.

Middle Eocene, older than Parisian.

.352 Sept. 29 On the Palæontology of Colorado. (Synopsis of result of work in connection with Hayden's U. S. Geological Survey during 1873.—Hay). *Proc. Acad. Nat. Sci. Phila.* Vol. XXVI, 1874, pp. 116, 117.

.353 Sept. 29 On some Batrachia and Nematognathi brought from the Upper Amazon by Professor Orton. *Proc. Acad. Nat. Sci. Phila.* Vol XXVI, 1874, pp. 120-137.

Describing two new batrachian genera, *Bubonias* and *Dysichthys.* Seventeen Nematognathi listed, seven described as new.

.354 Oct. 2 Remarks on *Brontotherium.* (Remarks of Professor Marsh's *Brontotherium ingens.*—Hay). *Proc. Amer. Philos. Soc.* Vol. XIV, 1874, p. 2.

Synonym of *Symborodon trigonoceras.*

.355 Oct. 2 Remarks on *Eobasileus galeatus* and on a Fossil Walrus. *Proc. Amer. Philos. Soc.* Vol. XIV, 1874, pp. 17, 18.

Exhibition of fragmentary skull and of walrus skull from Accomac, Va.

.356 Oct. 2 Abstract of Remarks of Professor Cope at the Meeting of the American Philosophical Society, January 16, 1874. *Proc. Amer. Philos. Soc.* Vol. XIV, 1874, p. 110.

*Poëbrotherium,* an ancestor of the Camelidæ.

.357 Oct. 20 Notes on the Santa Fé Marls, and some of the contained Vertebrate Fossils. *Proc. Acad. Nat. Sci. Phila.* Vol. XXVI, 1874, pp. 147-152. *Pal. Bull.* No. 18, pp. 147-152.

Six new species described: *Panolax* new genus.

.358 Nov. 28 Report upon the Vertebrate Fossils discovered in New Mexico with Descriptions of New Species. Note from Miss Brown's MSS. Issued as a separate (pp. 1-18) on November 28. The same paper as 324.

.359 Dec. 15 Extract of a Letter from Nacimento, New Mexico. *Proc. Acad. Nat. Sci. Phila.* Vol. XXVI, 1874, p. 163.

Notice of archaeological discoveries.

1875.360 Supplement to the Extinct Batrachia and Reptilia of North America. I—Catalogue of the Air-breathing Vertebrata from the Coal Measures of Linton, Ohio. *Trans. Amer. Philos. Soc.* n. s. Vol. XV, 1874, pp. 261-278.

.361 The Vertebrata of the Cretaceous Formations of the West. *Report, U. S. Geological Survey of the Territories* (Hayden) Vol. II, pp. 1-303, Pls. I-LVII and figs. 1-10 (4to.).

For a slightly changed form of pp. 7-14, see 375.

.362 On the Fishes of the Tertiary Shales of the South Park. *Bull. U. S. Geol. and Geogr. Survey of the Territories,* Ser. II, No. 1, pp. 3-5.

.363 Report on the Geology of that Part of Northwestern New Mexico examined during the field season of 1874. *Ann. Report upon the Geogr. Explorations and Surveys West of the 100th Meridian* . . . (Wheeler). Being Appendix LL of the Annual Report, Chief of Engineers for 1875, pp. 961-1097, Pls. II, V, VI, figs. 1-18. When Appendix LL, etc. was issued as a separate the pagination was pp. 61-116.

.364 Report on the Remains of a Population observed on and near the Eocene Plateau of Northwestern New Mexico. *Ann. Report upon the Geogr. and Geol. Explorations and Surveys West of the 100th Meridian* . . . (Wheeler), pp. 166-173, figs. 1-6. (Exactly the same text as 408. The figures are lacking in the former.)

.365 [Synopsis of the Genera Crotalus and Eutaenia, together with descriptions of one New Genus and Seven New Species]. Report upon the Collections of Batrachians and Reptiles made in portions of Nevada . . . during the years, 1871, 1872, 1873, 1874 by Dr. H. C. Yarrow. *Report, U. S. Geogr. Surveys West of the 100th Meridian* . . . (Wheeler) Vol. V, Chap. IV, pp. 532-536. (Material inserted in Yarrow's Chapter.) (4to.)

New genus is *Chilopoma* (preoccupied) now a synonym of *Thamnophis.*

.366 Report upon the Collection of Fishes made in Portions of Nevada, Utah, California, Colorado, New Mexico and Arizona during the years 1871, 1872, 1873 and 1874. (With H. C. Yarrow.) *Report, Geogr. and Geol. Explor. and Surveys West of the 100th Meridian* (Wheeler) Vol. V, Chapter VI, pp. 630-703, Pls. XXVI-XXXII (4to.).

Systematic arrangement with descriptions of all the fishes collected by all the naturalists of all the expeditions working in the states during the years named. Several new species are described.

.367 Check-List of North American Batrachia and Reptilia; with a Systematic List of the Higher Groups, and an Essay on Geographical Distribution, based on the specimens contained in the U. S. National Museum. *Bull. U. S. Nat. Museum*, No. 1, pp. 1-104.

.368 Synopsis of the Vertebrata whose Remains have been preserved in the Formations of North Carolina. *Rept. Geol. Survey, North Carolina,* W. C. Kerr, State Geologist, Appendix B., pp. 29-52, Pls. V-VIII.

.369 Synopsis of the Extinct Batrachia from the Coal Measures. *Rept. Geol. Survey Ohio* Vol. II (Palaeontology) Pt. II, pp. 349-411, Pls. XXVI-XLV, figs. 1-11.

.370 Report on the Vertebrate Fossils from the Fort Union Groups of Milk River. *Report* (of the British North American Boundary Commission), *on the Geology and Resources of the Region in the Vicinity of the 49th Parallel* (Dawson), Appendix B., pp. 333-337.

.371 New Forms of *Elasmosauridæ*. *Amer. Nat.* Vol. IX, 1875,
Jan. p. 55.
Review of Seeley.

.372 American Types in the Cretaceous of New Zealand. *Amer.*
Jan. *Nat.* Vol. IX, 1875, pp. 55, 56.
Review of Hector.

.373 A New Mastodon. *Amer. Nat.* Vol. IX, 1875, p. 56.
Jan. *M. productus* from Sante Fe—no description.

.374 The Wheeler Geological Survey of New Mexico for 1874.
Jan. *Amer. Nat.* Vol. IX, 1875, pp. 49-52.
Abstract report of Cope's party.

.375 The Value of Palaeontology. (The Significance of Palaeon-
Jan. tology—Cover Title.) *Penn Monthly.* Vol. VI, pp. 55-62.
A very slightly changed form of the introduction in 361.

.376 On a New Mastodon and Rodent. *Proc. Acad. Nat. Sci.*
Feb. *Phila.* Vol. XXVI, 1874, pp. 221-223. Abstracts, "A New
2 Mastodon," *Amer. Nat.* Vol. IX, 1875, p. 56.
Description of *Mastodon productus* and *Steneofiber pansus* from Santa Fe bed of New Mexico.

.377 On the Characters of *Symborodon*. *Proc. Acad. Nat. Sci.*
Feb. *Phila.* Vol. XXVI, 1874, p. 224.
2 Distinction from *Titanotherium.*

.378 On Dr. Leidy's "Correction". *Proc. Acad. Nat. Sci. Phila.*
Feb. Vol. XXVI, 1874, pp. 224, 225.
2 Concerning the relationships of *Thespesius* and *Ischyrosaurus.*

.379 Note on the Genus *Calamodon*. *Amer. Journ. Sci.* Ser. 3, Vol.
March IX, 1875, pp. 228, 229.

.380 Biological Research in the United States. *Penn Monthly,*
March Vol. VI, 1875, pp. 202-211.

.381 Systematic Catalogue of Vetebrata of the Eocene of New
April Mexico collected in 1874. *Report, Engineer Department,*
17 *U. S. Army* in charge of Lieut. Geo. M. Wheeler, pp. 1-37.
Extended report on Wasatch vertebrate fauna with descriptions of twenty-eight new species.

.382 On the Transition Beds of the Saskatchewan District. *Proc.*
April *Acad. Nat. Sci. Phila.* Vol. XXVII, 1875, pp. 9, 10.
20

.383 The Herpetology of Florida. *Proc. Acad. Nat. Sci. Phila.*
April Vol. XXVII, 1875, pp. 10, 11.
20 Florida as a distinct subdivision of the Austroriparian region.

.384 The Extinct Batrachia of Ohio. *Proc. Acad. Nat. Sci. Phila.*
April Vol. XXVII, 1875, p. 16.
20 *Pleuropteryx clavatus* and *Hyphasma laevis,* new genera and species, described, and a new species of *Ceraterpeton.*

.385 On Green-Sand Vertebrata. *Proc. Acad. Nat. Sci. Phila.*
April Vol. XXVII, 1875, p. 19.
20 Brief notice of crocodilia and chimaeroid fishes.

.386 On the Homologies of the Sectorial Tooth of Carnivora.
April *Proc. Acad. Nat. Sci. Phila.* Vol. XXVII, 1875, pp. 20-23.
20 Application of theories outlined in No. 335 to the evolution of carnassials. Primitive tibio-astragalar articulation in Eocene carnivora.

.387 The Feet of *Bathmodon*. *Proc. Acad. Nat. Sci. Phila.* Vol.
May XXVII, 1875, p. 73. Abstract, "On the Order Amblypoda",
11 *Amer. Nat.* Vol. IX, p. 427.

Characteristics of feet separate Bathmodon and its allies from Proboscidea as a distinct order, Amblypoda, with two suborders, Pintodonta (*Bathmodon*) and Dinocerata (*Uintatherium* and *Loxolophodon*).

.388 Synopsis of the Vertebrata of the Miocene of Cumberland
June County, New Jersey. *Proc. Amer. Philos. Soc.* Vol. XIV,
18 1875, pp. 361-364.

List with a few annotations. *Agabelus* gen. nov.

.389 On some New Fossil Ungulata. *Proc. Acad. Nat. Sci. Phila.*
June Vol. XXVII, 1875, pp. 258-261. *Pal. Bull.* No. 19, pp. 1-4.
28 Abstract, *Amer. Journ. Sci.* Ser. 3, Vol. X, 1875, p. 153.

*Pliauchenia* described with two species. *Hippotherium calamarium* and *Aphelops jemezanus* from Santa Fe marls, New Mexico.

.390 The Geology of New Mexico. *Pal. Bull.* No. 19, pp. 5-8.
June Lacks discussion contained in 396, but is otherwise the same.
28

.391 On an Indian Kitchenmidden. *Proc. Acad. Nat. Sci. Phila.*
July Vol. XXVII, 1875, p. 255.
27

.392 On Fossil Lemurs and Dogs. *Proc. Acad. Nat. Sci. Phila.* Vol.
July XXVII, 1875, pp. 255, 256.
27

*Sarcolemur* described (Bridger Eocene); *Canis* or *Amphicyon ursinus* from Santa Fe beds.

.393 On the Antelope-Deer of the Sante Fé Marls. *Proc. Acad.*
July *Nat. Sci. Phila.* Vol. XXVII, 1875, p. 257.
27

'*Dicrocerus*' (=Merycodus) from Santa Fe beds. This fauna probably Upper Miocene.

.394 The Phylogeny of the Camels. *Proc. Acad. Nat. Sci. Phila.*
July Vol. XXVII, 1875, pp. 261, 262.
27

Evolution of feet and teeth *Poëbrotherium, Procamelus, Pliauchenia, Camelus, Auchenia.*

.395 Consciousness in Evolution. *Penn Monthly.* Vol. VI, 1875,
July pp. 560-575.
31

.396 The Geology of New Mexico. *Proc. Acad. Nat. Sci. Phila.*
Aug. Vol. XXVII, 1875, pp. 263-268, 269. Abstract, *Amer. Journ.*
31 *Sci.* Ser. 3, Vol. X, 1875, pp. 152, 153.

A fuller form of 390. Brief note on Mesozoic and Tertiary in northern New Mexico, description of *Typothorax coccinarum.*

.397 On an Extinct Vulturine Bird. *Proc. Acad. Nat. Sci. Phila.*
Aug. Vol. XXVII, 1875, p. 271.
31 *Vultur umbrosus* described from Santa Fe marls.

.398 On the Cretaceous Beds of Gailsteo. *Proc. Acad. Nat. Sci.*
Sept. *Phila.* Vol. XXVII, 1875, pp. 359, 360.
28

.399 On the Batrachia and Reptilia of Costa Rica. *Journ.*
Nov. *Acad. Nat. Sci. Phila.* Ser. 2, Vol. VIII, 1875, pp. 93-154,
26 188, Pls. XXIII-XXVIII. Separates November 26, 1875.

New bufoniform genera *Cranopsis, Crepidins* and *Ollotis;* lacertilian genus, *Chalcidolepsis.* Synopses of *Conophis, Coniophanes, Rhadimaea, Tantilla,* and of the genera related to *Stenorhina.* The footnotes include descriptions of a number of new species from Mexico and the new lacertilian genus *Epaphelus.*

.400 On the Batrachia and Reptilia collected by Dr. John M.
Nov. Bransford during the Nicaraguan Canal Survey of 1874.
26 *Journ. Acad. Nat. Sci. Phila.* Ser. 2, Vol. VIII, 1875, pp. 155-157. Separates Nov. 26, 1875.

.401 Report on the Reptiles brought by Prof. James Orton from
Nov. the Middle and Upper Amazon, and Western Peru. *Journ.*
26 *Acad. Nat. Sci. Phila.* Ser. 2, Vol. VIII, 1875, pp. 159-183. Separates Nov. 26, 1875.

Including a new iguanid genus, *Scytomycterus.*

.402 Note on the Ichthyology of Lake Titicaca. *Journ. Acad.*
Nov. *Nat. Sci. Phila.* Ser. 2, Vol. VIII, 1875, pp. 185-187. Sepa-
26 rates Nov. 26, 1875.

*Orestias bairdii* and *O. ortonii* N. Sp.

.403 The Relation of Man to the Tertiary Mammalia. *Penn*
Dec. *Monthly* Vol. VI, 1875, pp. 879-886.

Read under the title "Indications of Descent Exhibited by the North American Tertiary Mammalia" before the A. A. A. S. Appears as title only in the Proc. A. A. A. S.

.404 On Fossil Remains of Reptiles and Fishes from Illinois.
Dec. *Proc. Acad. Nat. Sci. Phila.* Vol. XXVII, 1875, pp. 404-411.
21 Reprint, *Ann. & Mag. Nat. Hist.* Ser. 4, Vol. VII, 1876, pp. 178-184. Abstract, "Interesting Fossils from Illinois", *Amer. Nat.* Vol. IX, 1875, pp. 573, 574.

According to Cope this paper was issued in 1876. See, Cope. 1886.920, p. 286. *Ceratodus vinslooii* Cope.

.405 On the Supposed Carnivora of the Eocene of the Rocky
Dec. Mountains. *Proc. Acad. Nat. Sci. Phila* Vol. XXVII, 1875,
22 pp. 444-448. *Pal. Bull.* No. 20, pp. 1-4.
Characters of the Creodonta, proposed as a new suborder of Insectivora.

1876.406 On the Distribution of Batrachia and Reptilia in North America. *Proc. A. A. A. S.* XXIV Meeting, 1875, pp. 197-201.

.407 On a new Genus of Lophobranchiate Fishes. *Proc. Acad.*
Jan. *Nat. Sci. Phila.* Vol. XXVII, 1875, p. 450, Pl. XXV.
11 *Osphyolax.*

.408 On the Remains of Population observed on and near the
Feb. Eocene Plateau of Northwestern New Mexico. *Proc. Amer.*
4 *Philos. Soc.* Vol. XIV, 1875, pp. 475-482.
See 364.

.409 The Academy of Natural Sciences. *Penn. Monthly* Vol. VII
March 1876, pp. 173-180.

.410 On a Gigantic Bird from the Eocene of New Mexico. *Proc.*
April *Acad. Nat. Sci. Phila.* Vol. XXVIII, 1876, pp. 10, 11. *Amer.*
18 *Journ. Sci.* Ser. 3, Vol. XII, 1876, p. 306 and 493.
*Diatryma gigantea.*

.411 On the Theory of Evolution. *Proc. Acad. Nat. Sci. Phila.*
April Vol. XXVIII, 1876, pp. 15-17. Reprint, "The Progress of
18 Discovery of the Laws of Evolution," *Amer. Nat.* Vol. X, 1876, pp. 218-221. *Amer. Journ. Sci.* Ser. 3, Vol. XII, 1876, pp. 309-311.

.412 On the *Tæniodonta,* a New Group of Eocene Mammalia.
April *Proc. Acad. Nat. Sci. Phila.* Vol. XXVIII, 1876, p. 39.
25 Partly intermediate between Edentata and Insectivora. Two families. Ectoganidæ and Calamodontidæ. *Esthonyx* and *Anchippodus* related to *Erinaceus.*

.413 On the Geologic Age of the Vertebrate Fauna of New
April Mexico. *Proc. Acad. Nat. Sci. Phila.* Vol. XXVIII, 1876,
26 pp. 63-66. *Pal. Bull.* No. 21, pp. 1-3. *Journ. de Zoologie* Vol. V, 1876, pp. 307-311. *Amer. Journ. Sci.* Ser. 3, Vol. XII, 1876, pp. 297, 298.
Review of Wasatch fauna and comparison with Suessonian of Europe.

.414 On some Supposed Lemurine Forms of the Eocene Period.
July *Proc. Acad. Nat. Sci. Phila.* Vol. XXVIII, 1876, pp. 88, 89.
11 Suborder, Mesodonta based on combination of Creodont

and Primate characters of *'Tomitherium'* of New Mexican Wasatch. [This was due to finding mixed remains of a Creodont and a primate]. Order Bunotheria proposed to include Creodonta, Mesodonta, Insectivora, Tillodonta and Taeniodonta also perhaps Prosimiae.

.415 Academies of Science. *Penn Monthly,* Vol. VII, 1876, pp.
Aug. 640-647.

.416 On a New Genus of Fossil Fishes. *Proc. Acad. Nat. Sci.*
Aug. *Phila.* Vol. XXVIII, 1876, p. 113.
8 *Cyclotomodon vagrans* from phosphate beds of Charleston, S. C.

.417 Fourth Contribution to the History of the Existing Cetacea.
Sept. *Proc. Acad. Nat. Sci. Phila.* Vol. XXVIII, 1876, pp. 129-
5 139, Pls. III, IV, figs. 1-3.

.418 On a New Genus of Camelidae. *Proc. Acad. Nat. Sci. Phila.*
Sept. Vol. XXVIII, 1876, pp. 144-147.
5 *Protolabis,* type *P. heterodontus.*

.419 Descriptions of some Vertebrate Remains from the Fort
Nov. Union Beds of Montana. *Proc. Acad. Nat. Sci. Phila.*
13 Vol. XXVIII, 1876, pp. 248-261. *Pal. Bull.* No. 22, pp. 1-14.
*Ceratodus cruciferus, C. hieroglyphys,* new species, and *Mylidaphus bibartitus* new genus and species of fishes. Eighteen species described from Judith River formation, mostly dinosaur teeth; *Dysganus, Diclonius, Monoclonius, Paromychodon, Polythorax, Hedronchus,* new genera.

1877.420 Report upon the Extinct Vertebrata obtained in New Mexico by Parties of the Expedition of 1874. *Report, U. S. Geogr. Surveys West of the* 100*th Meridian* (Wheeler) Vol. IV, Part II, pp. 1-370, Pls. XXII-LXXXIII (4to).
*Syllænus latifrons* from Mesozoic; *Clastis aganus* and *C. integra* from Eocene.

.421 *Comparative Anatomy. (Frazer) *Johnson's New Universal Cyclopædia,* Vol. I, pp. 1053-1077, figs. 1-36.

.422 *Osteology (Frazer) *Johnson's New Universal Cyclopædia,* Vol. III, pp. 1008-1016, figs. 1-25.

.423 On some Extinct Reptiles and Batrachia from the Judith
Jan. River and Fox Hills Beds of Montana. *Proc. Acad. Nat.*
10 *Sci. Phila.* Vol. XXVIII, 1876, pp. 340-359. *Pal. Bull.* No. 23, pp. 1-20.
Fifteen species described, mostly from Judith River Cretaceous; *Zapsalis, Uronautes, Champsosaurus, Scapherpeton, Hemitrypus* new genera.

.424 Jan. 23 Explorations in South America. *Proc. Acad. Nat. Sci. Phila.* Vol. XXVIII, 1876, p. 264.
Notice of Orton's expedition.

.425 Jan. 23 Cretaceous Vertebrates of the Upper Missouri. *Proc. Acad. Nat. Sci. Phila.* Vol. XXVIII, 1876, p. 266.
Note on correlation of Judith River formation.

.426 Feb. The Suessonian Fauna in North America. *Amer. Nat.* Vol. XI, 1877, pp. 95-99.
General characters of Wasatch fauna compared with Suessonian of Europe.

.427 March 15 Reprint of Synopsis of Fishes of North Carolina with Addenda. March 1877, pp. 1-48.
Date taken from Introduction.

.428 March 19 A Continuation of Researches among the Batrachia of the Coal Measures of Ohio. *Proc. Amer. Philos. Soc.* Vol. XVI, 1877, pp. 573-578. *Pal. Bull.* No. 24, pp. 573-578.
*Ichthyacanthus* gen. nov. and a new species of *Leptophractus* and *Tuditamus* described.

.429 March 19 On a Dinosaurian from the Trias of Utah. *Proc. Amer. Philos. Soc.* Vol. XVI, 1877, pp. 579-584. *Pal. Bull.* No. 24, pp. 579-584.
*Dystrophæus viæmalæ.*

.430 March 19 On a New Proboscidian. *Proc. Amer. Philos. Soc.* Vol. XVI, 1877, pp. 584-585. *Pal. Bull.* No. 24, pp. 584, 585.
*Caenobasileus tremontigerus.* An artefact genus, based on fragments of Tertiary mastodon teeth incorrectly pieced together. See also 448.

.431 April 25 On the Brain of *Coryphodon. Proc. Amer. Philos. Soc.* Vol. XVI, 1877, pp. 616-620, Pls. I, II. Abstract, "The Lowest Mammalian Brain," *Amer. Nat.* Vol. XI, 1877, pp. 312, 313.
Description of the braincast of *C. elephantopus* from the New Mexican Wasatch. Separates April 25, 1877. Date from Miss Brown's MSS.

.432 May Discovery of *Laelaps* in Montana. *Amer. Nat.* Vol. XI, 1877, p. 311.
*L. incrassatus,* no description.

.433 May The Sea Serpents of the Cretaceous Period. *Amer. Nat.* Vol. XI, 1877, p. 311.
Notice of skelton of the *Elasmosaurus serpentinus* from Nebraska, and part of skeleton of *E. orientalis* from Upper Missouri.

.434 The Dentition of the Herbivorous *Dinosauria* of the Lignitic
May Period. *Amer. Nat.* Vol. XI, 1877, pp. 311, 312.
Characters of teeth in Trachodontidae.

.435 The Lowest Mammalian Brain. *Amer. Nat.* Vol. XI, 1877,
May p. 312.
Brief description of brain of *Coryphodon*.

.436 Report on the Geology of the Region of the Judith River,
May Montana, and on Vertebrate Fossils obtained on or near
15 the Missouri River. *Bull. U. S. Geol. and Geogr. Survey of the Territories,* Ser. III, No. 3, pp. 565-597, Pls. XXX-XXXIV.

.437 The Origin of the Will. *Penn Monthly,* Vol. VIII, 1877,
June pp. 435-455.

.438 On the Brain of *Procamelus occidentalis*. *Proc. Amer. Philos.*
June *Soc.* Vol. XVII, 1877, pp. 49-52, Pl. I.
15 Description of the braincast of *P. "occidentalis"* from the Upper Tertiary of New Mexico (Santa Fe beds). Separates June 15, 1877. Date from Miss Brown's MSS.

.439 On the Classification of the Recent and Fossil Fishes. *Amer.*
Aug. *Nat.* Vol. XI, 1877, p. 501.
Abstract of .491.

.440 On a Carnivorous Dinosaurian from the Dakota Beds of Colo-
Aug. rado. *Bull. U. S. Geol. and Geogr. Survey of the Territories,*
15 Ser. III, No. 4, pp. 805, 806.

.441 A Contribution to the Knowledge of the Ichthyological
Aug. Fauna of the Green River Shales. *Bull. U. S. Geol. and*
15 *Geogr. Survey of the Territories,* Ser. III, No. 4, pp. 807-819. Abstract, "Verbal Communication on a New Locality of the Green River Shales containing Fishes, Insects and Plants in a good state of Preservation," *Pal. Bull.* No. 25, p. 1. Reprinted abstract, "New Fossil Fishes from Wyoming," *Amer. Nat.* Vol. XI, 1877, p. 570.
Sixteen fishes described including 5 new genera and 14 new species.

.442 On the Genus *Erisichthe*. *Bull. U. S. Geol. and Geogr. Survey*
Aug. *of the Territories,* Ser. III, No. 4, pp. 821-823.
15 Discussion of the fragmentary remains on which 4 species have been erected.

.443 On a New Species of Adocidae from the Tertiary of Georgia.
Aug. *Proc. Amer. Philos. Soc.* Vol. XVII, 1877, pp. 82-84. *Pal.*
23 *Bull.* No. 25, pp. 2-4.
*Amphiemys* gen. nov.

.444 On a gigantic Saurian from the Dakota Epoch of Colorado.
Aug. *Pal. Bull.* No. 25, pp. 5-10.
23 First description of *Camarasaurus supremus* from the Morrison formation near Cañon City, Colorado. Based upon vertebrae. This is a little later than Marsh's first description of an Opisthocoelian (Sauropod) dinosaur from near Morrison, Colo. Marsh, however, used a pre-occupied name (Titanosaurus) so that Cope's name is the earliest available name for an American Opisthocoelian.

.445 Fossil Remains of a Dinosaur. *Proc. Amer. Philos. Soc.*
Aug. Vol. XVI, 1877, pp. 386, 391.
31 Notice of exhibit and title of a paper.

.446 Scratched Figures on Coal Shales. *Proc. Amer. Philos. Soc.*
Aug. Vol. XVI, 1877, p. 391.
31 Notice of *Dystrophaeus* (no name); and of Indian drawings from a mound near Davenport, Iowa.

.447 Vertebral Column of *Elasmosaurus*. *Proc. Amer. Philos.*
Aug. *Soc.* Vol. XVI, 1877, pp. 393, 394. Abstract, "Sea Serpents
31 of the Cretaceous Period," *Amer. Nat.* Vol. XI, 1877, p. 311.
Exhibtion of *Elasmosaurus serpentinus* skeleton, name, no description.

.448 New Species of Mastodon. *Proc. Amer. Philos. Soc.* Vol.
Aug. XVI, 1877, p. 394.
31 See also 430. Notice of *M. tremontinus*—no description [probably meant for "*Caenobasileus tremontigerus*"].

.449 Cast of the Brain Cavity of *Coryphodon elephantopus*. *Proc.*
Aug. *Amer. Philos. Soc.* Vol. XVI, 1877, p. 395.
31

.450 Rare Snakes from Florida. *Amer. Nat.* Vol. XI, 1877,
Sept. p. 565.
Notice of an efficient collector.

.451 The Largest Known Saurian. *Amer. Nat.* Vol. XI, 1877,
Oct. p. 629.

.452 On some New or Little Known Reptiles and Fishes of the
Nov. Cretaceous No. 3, of Kansas. *Proc. Amer. Philos. Soc.*
21 Vol. XVII, 1877, pp. 176-181. *Pal. Bull.* No. 26, pp. 176-181.
Descriptions of species of *Toxochelys* (Chelonia), *Ichthyodectes, Anogmius,* and *Oricardinus,* etc. (Pisces.)

.453 Descriptions of Extinct Vertebrata from the Permian and
Nov. Triassic Formations of the United States. *Proc. Amer.*
21 *Philos. Soc.* Vol. XVII, 1877, pp. 182-193. *Pal. Bull.*
No. 26, pp. 182-193 and p. 196. (In the Bulletin the last

paragraph of the original paper is appended at the end of the second article.) Abstract, "Remains of a Huge Saurian in Pennsylvania", *Amer. Nat.* Vol. XI, 1877, p. 629.

Teeth of dinosaurs, etc., from Phœnixville, Pa.; Permian vertebrates from Illinois; *Eryops* skull and skeleton from Permian ("Triassic") of Texas.

.454 Nov. 21 On Reptilian Remains from the Dakota Beds of Colorado. *Proc. Amer. Philos. Soc.* Vol. XVII, 1877, pp. 193-196. *Pal. Bull.* No. 26, pp. 193-196 (For final paragraph see explanation given for 453).

*Caulodon* (teeth of *Camarasaurus*) and other vertebrates from Morrison formation, Cañon City, Col.; *"Clepsydrops" limbatus* from the Permian of Texas.

.455 Dec. 10 On *Amphicœlias,* a Genus of Saurians from the Dakota Epoch of Colorado. *Pal. Bull.* No. 27, pp. 2-5.

Description of *A. altus* and *"A." latus.* Republished, *Proc. Amer. Philos. Soc.* Vol. XVII, pp. 242-246, and also as *Pal. Bull.* No. 28, same pagination. See 463.

1878.456 Jan. The Relation of Animal Motion to Animal Evolution. *Amer. Nat.* Vol. XII, 1878, pp. 40-48.

The structure of animals is directly modified by their movements, and in adaptation to their habits and environment. [No clear distinction is made between the effects on the individual and upon the phylum.]

.457 Jan. The Saurians of the Dakota Epoch. *Amer. Nat.* Vol. XII, 1878, pp. 56, 57.

Summary of 455.

.458 Jan. *Clepsydrops* in Texas. *Amer. Nat.* Vol. XII, 1878, p. 57.

.459 Jan. The Affinities of the Dinosauria. *Amer. Nat.* Vol. XII, 1878, pp. 57, 58. (Cited by Hay.)

Comments upon Owen's discussion in article describing *Omosaurus.*

.460 Jan. Mount Lebanon Fishes in Dakota. *Amer. Nat.* Vol. XII, 1878, p. 57.

Summary of article in *Bull. U. S. Geol. Survey.* Identity of genera in Mt. Lebanon, Dakota and Westphalia deposits.

.461 Jan. 12 Descriptions of New Vertebrata from the Upper Tertiary Formation of the West. *Proc. Amer. Philos. Soc.* Vol. XVII, 1877, pp. 219-231. *Pal. Bull.* No. 28, pp. 219-231. Abstracts, "New Artiodactyle of the Upper Tertiary."

*Amer. Nat.* Vol. XII, 1878, p. 58; and "A New Mastodon", Ibid, p. 128.

First descriptions of Deep River fauna (Montana) and Republican River fauna (Kansas-Nebraska); new species from Pleistocene of Oregon and Washington. Two new species each of Cyprinoid genera, *Anchybopsis* and *Alburnops*. First abstract includes tenable descriptions of *Pithecistes, Cyclopidius* and *Brachymeryx* new genera. Second abstract, tenable description of *Tetralophodon campistus*.

.462 Jan. 12 On some Saurians found in the Triassic of Pennsylvania by C. M. Wheatley. *Proc. Amer. Philos. Soc.* Vol. XVII, 1877, pp. 231, 232. *Pal. Bull.* No. 28, pp. 231, 232. Abstract, "Triassic Saurians from Pennsylvania", *Amer. Nat.* Vol. XII, 1878, p. 58.

Dinosaur teeth from Phœnixville, Pa.

.463 Jan. 12 On the Vertebrata of the Dakota Epoch of Colorado. *Proc. Amer. Philos. Soc.* Vol. XVII, 1877, pp. 233-247, Pls. (1)-(9). *Pal. Bull.* No. 28, pp. 233-247 (Does not contain plates).

Revised descriptions of *Camarasaurus, Amphicoelias* etc., from Morrison formation, Cañon City, Col. See also 455.

.464 Jan. 31 On the Saurians recently discovered in the Dakota Beds of Colorado. *Amer. Nat.* Vol. XII, 1878, pp. 71-85, figs. 1-6, 9-17.

Descriptions with figures of *Camarasaurus* and *Amphicoelias,* description of *Tichosteus.*

.465 Jan. 31 Pliocene Man. (Read before the Amer. Philos. Soc.) *Amer. Nat.* Vol. XII, 1878, pp. 125, 126. *Proc. Amer. Philos. Soc.* Vol. XVII, 1878, p. 292.

List of species of fossil mammals (Lower Pleistocene) found with obsidian arrow heads [Fossil Lake, Oregon]. While the *Proc. Amer. Philos. Soc.* is supposed to contain the original and the *Amer. Nat.* the reprint, the latter was the first to be published apparently.

.466 Jan. 31 Palaeontology of Georgia. *Amer. Nat.* Vol. XII, 1878, p. 128.

Note on position of *Erisichthe.* Cited by Hay.

.467 Jan. 31 The Snout of Fishes from the Kansas Chalk. *Amer. Nat.* Vol. XII, 1878, p. 129.

Abstract, eight lines.

.468 Jan. 31 A New Genus of Oreodontidæ. *Amer. Nat.* Vol. XII, 1878, p. 129.

Description of *Ticholeptus zygomaticus,* gen. et sp. nov. from Deep River beds of Montana.

.469 Jan. 31 Note on Fossils obtained by Mr. Russell S. Hill, including Bones of *Protestega gigas*. *Amer. Nat.* Vol. XII, 1878, p. 137. Cited by Hay.

.470 Feb. 5 Descriptions of Fishes from the Cretaceous and Tertiary Deposits west of the Mississippi River. *Bull. U. S. Geol. and Geogr. Survey of the Territories,* Ser. IV, No. 1, pp. 67-77.

Two new genera and eleven new species described.

.471 Feb. 5 Professor Owen on the *Pythonomorpha*. *Bull. U. S. Geol. and Geogr. Survey of the Territories,* Ser. IV, No. 1, pp. 299-311.

.472 March A Texas Cliff Frog. *Amer. Nat.* Vol. XII, 1878, p. 186.

*Lithodytes* n. sp. Note on habits.

.473 March A New Genus of *Dinosauria* from Colorado. *Amer. Nat.* Vol. XII, 1878, pp. 188, 189.

Description of *Hypsirophus obscurus* gen. et sp. nov.

.474 March A New Deer from Indiana. *Amer. Nat.* Vol. XII, 1878, p. 189.

Description of *Cariacus dolichopsis* n. sp. from Pleistocene of Indiana.

.475 March 9 Synopsis of the Cold Blooded Vertebrata, procured by Prof. James Orton during his Exploration of Peru in 1876-1877. *Proc. Amer. Philos. Soc.* Vol. XVII, 1877, pp. 33-49.

Nineteen fishes listed, eight being new.

.476 March 9 Reptilian Bone Bed in Eastern Illinois. (On the Vertebrata of the Bone Bed in Eastern Illinois.) *Proc. Amer. Philos. Soc.* Vol. XVII, 1877, pp. 2, 52-63.

.477 March 9 On some New and Little Known Reptiles and Fishes from the Austroriparian Region. *Proc. Amer. Philos. Soc.* Vol. XVII, 1877, pp. 63-68.

Nine batrachians, twenty-six reptiles and eleven fishes from Georgia, South Carolina, Florida. Two new species of *Lepomis,* and *Xystroplites longimanus* Nov. Gen. et Sp. described.

.478 March 9 Tenth Contribution to the Herpetology of Tropical Ameriica. *Proc. Amer. Philos. Soc.* Vol. XVII, 1877, pp. 85-98.

.479 April Contribution to the Fossil Flora of the Western Territories. Part II, The Tertiary Flora, by Leo Lesquereux (Review). *Amer. Nat.* Vol. XII, 1878, pp. 243-246.

Criticism of Lesquereux' conclusions upon the Cretaceous-Tertiary boundary formations in the Rocky Mountain region.

.480 April A New Genus of Cystignathidæ from Texas. *Amer. Nat.* Vol. XII, 1878, pp. 252, 253.

*Syrrhopus marnockii.*

.481 May The Homology of the Chevron Bones. *Amer. Nat.* Vol. XII, 1878, p. 319.

Chevron bones are homologous with intercenta of dorsal and cervical vertebræ of Permian reptiles.

.482 May The Structure of *Coryphodon*. *Amer. Nat.* Vol. XII, 1878, pp. 324-326. Abstract, *Nature*, Vol. XVIII, 1878, p. 67.

Reply to Marsh's criticism in *Nature*, Vol. XVII, 1878, p. 340, of Cope's description of brain and foot structure of this genus.

.483 May 3 Descriptions of New Extinct Vertebrata from the Upper Tertiary and Dakota Formations. *Bull. U. S. Geol. and Geogr. Survey of the Territories*, Ser. IV, No. 2, pp. 379-396.

.484 May 8 Descriptions of Extinct Batrachia and Reptilia from the Permian Formation of Texas. *Proc. Amer. Philos. Soc.* Vol. XVII, 1878, pp. 505-530. *Pal. Bull.* No. 29, pp. 505-530. Abstract, "A New Fauna," *Amer. Nat.* Vol. XII, 1878, pp. 327, 328.

Descriptions of *Diadectes, Bolosaurus, Pariotichus, Ectocynodon, Clepsydrops natalis* skeleton, *Dimetrodon, Epicordylus* (=*Eryops*), *Empedocles* (=*Diadectes*), *Theropleura, Parioxys, "Cricotus heteroclitus", Zatrachys, Trimerorhachis, Rachitomus* (=*Eryops*), etc. With the exception of *Eryops*, these are the first descriptions of the Texas Permian fauna.

.485 June A New Opisthocoelous Dinosaur. *Amer. Nat.* Vol. XII, 1878, p. 406. *Reprint, Ann. & Mag. Nat. Hist.* Ser. 5, Vol. II, 1878, p. 194.

Description of *Epanterias amplexus* gen. et sp. nov. from Morrison formation, Cañon City, Col.

.486 June Prof. Marsh on Permian Reptiles. *Amer. Nat.* Vol. XII, 1878, pp. 406-408.

Criticism of Marsh's paper in *Amer. Journ. Sci.* for May, 1878.

.487 June Fossorial Reptiles. *Amer. Nat.* Vol. XII, 1878, p. 408.

Humeri of certain Permian reptiles appear to be of fossorial type.

.488 Synopsis of the Fishes of the Peruvian Amazon, obtained
June by Prof. Orton during his Expeditions of 1873 and 1877.
10 *Proc. Amer. Philos. Soc.* Vol. XVII, 1878, pp. 673-701.
One hundred and twenty species listed from upper Amazon. Three new genera and thirty new species established.

.489 Proceedings of the Academy of Natural Sciences of Phila-
July delphia, September to December 1877. *Amer. Nat.* Vol. XII, 1878, pp. 459-461.
Critical comment on President's Annual Report. Unsigned Review. Cited by Frazer.

.490 The Species of Rhinoceros of the Loup Fork Epoch. *Amer.*
July *Nat.* Vol. XII, 1878, pp. 488, 489.
Diagnosis of *Aphelops fossiger* and *malacorhinus* from Republican River beds of Kansas.

.491 On the Classification of the Extinct Fishes of the Lower
Aug. Types. *Proc. A. A. A. S.* XXVI Meeting, 1877, pp. 292-300. (For abstract see 439.)
Critical discussion of bases of differentiation between the lower forms of fishes.

.492 The Report of the Committee of the American Association
Aug. of 1876 on Biological Nomenclature. *Amer. Nat.* Vol. XII, 1878, pp. 517-525.
Results of a questionnaire.

.493 Review—The Relation of the Mosaic Cosmography to Sci-
Aug. ence, by C. B. Warring, Ph. D. *Amer. Nat.* Vol. XII, 1878, pp. 547-549. Unsigned. Cited by Frazer.

.494 Note on the Prong-Horned Antelope. *Amer. Nat.* Vol. XII,
Aug. 1878, p. 557.
Shedding of the horns is not periodical or even frequent.

.495 A New Species of *Amphicœlias.* *Amer. Nat.* Vol. XII, 1878,
Aug. pp. 653, 654, 1 fig.
Description of A. *fragillimus* from Morrison beds near Cañon City, Col. [part of a gigantic vertebrate].

.496 A New *Diadectes.* *Amer. Nat.* Vol. XII, 1878, p. 565.
Aug. Description of *D. molaris* from Permian of Texas. Unsigned. Cited by Hay and Frazer.

.497 Des rapports entre le mouvement et l'évolution chez les
Aug. animaux. *Revue internat. des Sciences,* Tre Anné, No. 31,
1 pp. 138-141. See 456.

.498 On the Saurians of the Dakota Cretaceous Rocks of Colo-
Aug. rado. *Nature,* Vol. XIII, Aug. 29, p. 476. *Proc. British*
29 *A. A. S.* 1878, p. 545.
Abstract of paper read before British A. A. S. 1878.

.499 On the Remains of a Permian Fauna in North America.
Aug. *Nature,* Vol. XIII, Aug. 29, 1878, p. 482.
29 Abstract of paper read before the British A. A. S. Title only in Proc. British A. A. S. 1878, p. 571.

.500 The Vertebræ of *Rachitomus.* *Amer. Nat.* Vol. XII, 1878,
Sept. p. 633.
Construction of the vertebræ. *Eryops* is probably similar.

.501 A Fossil Walrus discovered at Portland, Maine. *Amer.*
Sept. *Nat.* Vol. XII, 1878, p. 633.
Notice of discovery. Skeleton in Museum of Portland Nat. Hist. Soc. Unsigned. Cited by Hay.

.502 The Herpetology of New Guinea. *Amer. Nat.* Vol. XII,
Nov. 1878, p. 751.
Review of an article by H. E. Sauvage in the Bulletin, Société philomatique, Paris.

.503 The Fauna of the Lowest Tertiary of France. *Amer. Nat.*
Nov. Vol. XII, 1878, pp. 761, 762.
Notice of the palæontological discoveries of Dr. Lemoine in the Lowest Tertiary of France.

.504 The Excursions of the Geological Society of France for
Dec. 1878. *Amer. Nat.* Vol. XII, 1878, pp. 771-776.

.505 The Principal Characters of American Cretaceous Dino-
Dec. saurs. *Amer. Nat.* Vol. XII, 1878, pp. 811, 812.
Critical review of Marsh's paper in Amer. Journ. Sci. with this title. Unsigned. Cited by Frazer.

.506 The Theromorphous Reptilia. *Amer. Nat.* Vol. XII, 1878,
Dec. pp. 829, 830.
Abstract with diagnoses of orders and suborders; *Dimetrodon cruciger* sp. nov. from Permian of Texas. Abstract of paper read before the National Academy of Sciences, Nov. 7, 1878.

.507 On some of the Characters of the Miocene Fauna of Oregon.
Dec. *Proc. Amer. Philos. Soc.* Vol. XVIII, 1878, pp. 63-78.
26 *Pal. Bull.* No. 30, pp. 1-16. Abstract, "Miocene Vertebrata of Oregon," *Amer. Nat.* Vol. XII, 1878, p. 833.
Based upon collections of Sternberg, Wortman and Day in

the John Day basin. Chiefly Rodents, Carnivores and Horses
from the John Day formation.

1879.508 Palæontological Report of the Princeton Scientific Expedi-
Jan. tion of 1877. *Amer. Nat.* Vol. XIII, 1879, pp. 32, 33.
4 Unsigned Review of "Contributions from the Museum of
Geology and Archæology of Princeton College. No. 1-,
Palæontological Report etc., by Henry F. Osborn, W. B.
Scott and Francis Spier, Jr." Cited by Hay.

.509 Letter from O. C. Marsh, etc. transmitting the Report on
Jan. the Scientific Surveys of the Territories. *Amer. Nat.* Vol.
4 XIII, 1879, pp. 35-37.
Review of, "Letter from O. C. Marsh, vice-president and
acting president of the National Academy of Sciences, transmitting, in obedience to law, the Report on the Scientific
Surveys of the Territories made by the National Academy of
Sciences, Senate Mis. Doc. No. 19." Objections to plan for
discontinuance of existing U. S. geological surveys and replacement by a new survey.

.510 Extinct Mammalia of Oregon. *Amer. Nat.* Vol. XIII, 1879,
Feb. p. 131.
4 Tenable description of *Enhydrocyon* gen. nov. For full
paper see 516.

.511 The Necks of Sauropterygia. *Amer. Nat.* Vol. XIII, 1879,
Feb. p. 132.
4 Progressive shortening of the neck during the Cretaceous.

.512 The Scales of *Liodon*. *Amer. Nat.* Vol. XIII, 1879, p. 132.
Feb. Six lines.
4 Unsigned. A brief note calling attention to observations
of Professor Snow and to his paper in Review of Science
and Industry—Hay.

.513 The Origin of the Specialized Teeth of the Carnivora.
Feb. *Amer. Nat.* Vol. XIII, 1879, pp. 171-173. *Ann. & Mag. Nat.*
27 *Hist.* Ser. 5, Vol. III, 1879, pp. 391, 392.
Explanation of the mechanical causes operating to evolve
the carnassial teeth.

.514 *Merycopater* and *Hoplophoneus*. *Amer. Nat.* Vol. XIII,
Feb. 1879, p. 197.
27 Note on John Day fossil mammalia. *Merycopater* gen.
nov. (=*Agriochærus*); *Machærodus brachyops* transferred
to *Hoplophoneus*.

.515 The Relations of the Horizons of Extinct Vertebrata of
Feb. Europe and North America. *Bull. U. S. Geol. and Geogr.*
28 *Survey of the Territories*, Ser. V, No. 1, pp. 33-54.

.516 Feb. 28 Observations on the Faunæ of the Miocene Tertiaries of Oregon. *Bull. U. S. Geol. and Geogr. Survey of the Territories.* Vol. V, No. 1, pp. 55-69.

For abstract see 510.

.517 March 13 A Review of the Modern Doctrine of Evolution. (Read before the California Academy of Sciences, October 27, 1879.) *"*Scientific Press" Supplement*, November, 1879, pp. 1-28. Abstract, *Amer. Nat.* Vol. XIV, 1880, pp. 166-179, 260-271; 27 figs. *Separates, Philadelphia, March 13, 1880, pp. 166-178, 261-272; 27 figs. (Date from Miss Brown's MSS.)

The evidence for evolution—ontogeny and phylogeny; the laws of evolution—acceleration—adaptation—kinetogenesis; the metaphysics of evolution; the morals of evolution.

.518 March 26 A New Genus of Perissodactyla. *Amer. Nat.* Vol. XIII, 1879, pp. 270, 271.

*Anchisodon* gen. nov. type *Hyracodon quadriplicatus* from White River beds of N. E. Colorado.

.519 March 26 New Genus of Ichthyopterygia. *Amer. Nat.* Vol. XIII, 1879, p. 271.

Notice of Marsh's article describing *Sauranodon* gen. nov. (=*Baptanodon*). Unsigned. Cited by Hay.

.520 April Une lettre de M. Cope (de Philadelphie) au suject d'une question de priorité relative à l'emploi des noms de *Dinoceras* et de *Brontotherium*. *Le Naturaliste,* Vol. I, No. 1, 1879, pp. 2, 3.

.521 April 22 Statements in Regard to the Bulletin of the U. S. Geological and Geographical Survey of the Territories, Vol. VI, No. I. *Proc. Amer. Philos. Soc.* Vol. XVIII, 1879, p. 211.

.522 May The Amyzon Tertiary Beds. *Amer. Nat.* Vol. XIII, 1879, p. 332.

Amyzon fish fauna distinct from that of Green River, probably later than Bridger horizon.

.523 May Gaudry on Permian Vertebrata. *Amer. Nat.* Vol. XIII, 1879, pp. 332, 333.

*Actinodon* Gaudry compared with *Rhachitomus* Cope (= *Eryops*) and *Euchirosaurus* with *Dimetrodon* of Texas Permian. Unsigned. Given on Dr. Matthew's authority.

.524 May A Sting Ray from the Green River Shales of Wyoming. *Amer. Nat.* Vol. XIII, 1879, p. 333.

*Xiphotrygon acutidens* described.

.525 American Aceratheria. *Amer. Nat.* Vol. XIII, 1879, pp.
May 333, 334.
*Aceratherium* (=*Cænopus*) *truguianum* n. sp. described from John Day formation of Oregon. Diagnosis of *Aphelops*.

.526 The Lower Jaw of *Loxolophodon*. *Amer. Nat.* Vol. XIII,
May 1879, p. 334.
Notice of article in *Amer. Journ. Sci.* by Osborn and Spier.

.527 New Jurassic Dinosauria. *Amer. Nat.* Vol. XIII, 1879, pp.
May 402-404, 3 cuts.
20 *Camarasaurus leptodirus* and *Hypsirhophus seeleyanus* described from Morrison beds near Cañon City, Col.

.528 Vertebræ of a New Species of *Camelosaurus*. *Proc. Amer.*
June *Philos. Soc.* Vol. XVIII, 1879, p. 211.
3

.529 A Contribution to the Zoology of Montana. *Amer. Nat.*
June Vol. XIII, 1879, pp. 432-441.
17 Notes chiefly on amphibian and fish fauna in parts of Western Montana.

.530 Ryder on the Mechanical Genesis of Tooth Forms. *Amer.*
June *Nat.* Vol. XIII, 1879, pp. 446-449.
17 Review of articles by John A. Ryder in *Proc. Acad. Nat. Sci. Phila.*, 1878-9. Kinetogenesis. Unsigned. Given on Dr. Matthew's authority.

.531 Another *Siredon*. *Amer. Nat.* Vol. XIII, 1879, pp. 456, 457.
June *Siredon tigrinus* Velasco, probably identical with *Ambly-*
17 *stoma mavortium* Baird.

.532 *Lota maculosa* in the Susquehanna River. *Amer. Nat.* Vol.
June XIII, 1879, p. 457.
17

.533 A New *Anchitherium*. *Amer. Nat.* Vol. XIII, 1879, pp.
June 462, 463.
17 *A. præstans* described from John Day formation of Oregon. Type of *Kalobatippus* Osborn, 1916.

.534 A Decade of Dogs. *Amer. Nat.* Vol. XIII, 1879, p. 530.
Aug. List of ten species from John Day formation, Oregon.

.535 The Modern Museum. *Penn Monthly* Vol. X, 1879, pp.
Aug. 598-605.

.536 Eleventh Contribution to the Herpetology of Tropical Amer-
Aug. ica. *Proc. Amer. Philos. Soc.* Vol. XVIII, 1879, pp. 261-277.
11 For the states of Chihuahua, Guanjuato, and the Isthmus

of Tehuantepec, Mexico, Costa Rica, Santa Domingo, Dominica, Tobago, and northwest Bolivia. Including the new genera of snakes, *Procinura* and *Malachylodes* from Mexico, and synopses of the genera *Syrrhophus* and *Cystignathus*.

.537 Aug. 12 On the Genera of Felidæ and Canidæ. *Proc. Acad. Nat. Sci. Phila.* Vol. XXXI, 1879, pp. 168-184 (published Aug. 12), pp. 185-194 (published Nov. 4). *Ann. & Mag. Nat. Hist.*, Ser. 5, Vol. V, 1880, pp. 36-45, 92-108.

.538 Sept. 6 On the Extinct Species of *Rhinocerida* of North America and their Allies. (Read before the National Academy of Sciences, April, 1879.) *Bull. U. S. Geol. and Geogr. Survey of the Territories,* Ser. V. No. 2, pp. 227-237. An adaptation of this paper, "On the Extinct American Rhinoceroses and their Allies," appeared in *Amer. Nat.* Vol. XIII, 1879, pp. 771a-771j, figs. 1-8. Abstract, *Science News* Vol. I, p. 221.

American Naturalist article contains figures of *Aphelops fossiger, megalodus* and *malacorhinus* skulls.

.539 Oct. The California Gray Whale. *Amer. Nat.* Vol. XIII, 1879, p. 655.

.540 Oct. The Japanese Dog. *Amer. Nat.* Vol. XIII, 1879, pp. 655, 656.

*Dysodus pravus,* additional notes upon.

.541 Dec. The Fishes of Klamath Lake, Oregon. *Amer. Nat.* Vol. XIII, 1879, pp. 784, 785.

Annotated list of species found.

.542 Dec. The Cave Bear of California. *Amer. Nat.* Vol. XIII, 1879, p. 791. Reprint, *Ann. & Mag. Nat. Hist.*, Ser. 5, Vol. V, 1880, pp. 260, 261. Reprint, *Amer. Journ. Sci.* Vol. XIX, 1880, p. 155.

Description of *Arctotherium simum* sp. nov. from Shasta Co., Cal.

.543 Dec. Scientific News. *Amer. Nat.* Vol. XIII, 1879, pp. 798a, 798b. Unsigned. Cited by Hay and Frazer.

Report of Cope's exploration of John Day, N. E. Colorado, and Cañon City fossil fields. Descriptions of *Archælurus debilis* and *Hoplophoneus platycopis.*

.544 Dec. California Academy of Sciences, November 3. *Amer. Nat.* Vol. XIII, 1879, pp. 800, 801.

Remarks on *Arctotherium simus* and *Xantusia riversiana.*

.545 Dec. 4 Second Contribution to a Knowledge of the Miocene Fauna of Oregon. *Proc. Amer. Philos. Soc.* Vol. XVIII, 1879, pp. 370-376. *Pal. Bull.* No. 31, pp. 1-7 (this was the first to be published). Abstract, "Miocene Fauna of Oregon," *Amer. Nat.* Vol. XIV, 1880, p. 60.

Continuation of researches upon collections made by Wortman, Sternberg and Day in 1878-9 in the John Day basin. Chiefly descriptions of carnivora, rodents, peccaries and Agriochoeri from the John Day formation.

1880.546 Sur les Relations des niveaux de vertébrés éteints dans l'Amerique du Nord et en Europe. *Comptes rendus, Congrés internat. de Géol.*, Paris, 1878, pp. 144-164.

.547 Sur le Report of the Committee of the American Association of 1876 on Biological Nomenclature. *Comptes rendus, Congrés internat. de Géol.*, Paris, 1878, pp. 268-271.

.548 On the Zoological Position of Texas. *Bull. U. S. Nat. Museum*, No. 17, pp. 1-51.

.549 Jan. 2 (On the Proposed Reorganization of the Philadelphia Academy of Natural Sciences.) Unsigned. *Amer. Nat.* Vol. XIV, 1880, pp. 38-42, 356-359.

.550 Jan. 2 Pliocene Man. [Remarks on fossil Vertebrates from California, *Elotherium, Mastodon obscurus*—Hay.] *Amer. Nat.* Vol. XIV, 1880, pp. 60-62.

.551 Jan. 31 Hill's Kansas Expeditions. *Amer. Nat.* Vol. XIV, 1880, pp. 141, 142.

Unsigned. Cited by Hay and Frazer. Notice of collections made in Republican River basin.

.552 Jan. 31 Hulke on *Ornithopsis* of Seeley. *Amer. Nat.* Vol. XIV, 1880, p. 142.

Unsigned. Cited by Frazer. Notice of Hulke's paper, *Q. J. G. S.* Vol. 35, pp. 752-762.

.553 Jan. 31 Filhol on the Fauna of St. Gerand le Puy. *Amer. Nat.* Vol. XIV, 1880, p. 142.

Unsigned. Cited by Frazer. Notice of Filhol's Memoir in *Ann. Sci. Géol.* Vol. X, No. 3, 1879, Vol. XI.

.554 Jan. 31 Notes on Sabre-tooths. *Amer. Nat.* Vol. XIV, 1880, pp. 142, 143.

*Pogonodon* gen. nov. and *Hoplophoneus cerebralis* sp. nov. from John Day formation of Oregon.

.555 Feb. 25 [Tariff on Scientific Apparatus.] *Amer. Nat.* Vol. XIV, 1880, pp. 190-192.

Unsigned editorial. Cited by Frazer. Scientific specimens and apparatus should be admitted free whether or not intended for sale.

.556 The Refutation of Darwinism. *Amer. Nat.* Vol. XIV, 1880,
Feb. pp. 192, 193.
25 Unsigned. Review of, "The Refutation of Darwinism and the Converse Theory of Development, based exclusively upon Darwin's Facts, etc., by T. Warren O'Neill." Cited by Frazer.

.557 A New *Hippidium*. *Amer. Nat.* Vol. XIV, 1880, p. 223.
Feb. *H. spectans* from John Day basin of Oregon (Rattlesnake
25 formation) now referred to *Pliohippus*.

.558 On the Foramina perforating the Posterior Part of the
March Squamosal Bone of the Mammalia. *Proc. Amer. Philos. Soc.*
2 Vol. XVIII, 1880, pp. 452-461, figs. 1-6. Abstract, *Amer. Nat.* Vol. XIV, 1880, pp. 287, 288.

Taxonomic value of the squamosal foramina. Pp. 452-456 appeared on March 2; pp. 457-461, March 6.

.559 Marsh on Jurassic Dinosauria. *Amer. Nat.* Vol. XIV, 1880,
March p. 302.
21 Unsigned. Cited by Hay and Frazer. Notice of Marsh's article on *Stegosaurus* in Amer. Journ. Sci. (3) Vol. XIX, pp. 253-259, Pl. VI-XI.

.560 The Manti Beds of Utah. *Amer. Nat.* Vol. XIV, 1880, pp.
March 303, 304.
21 May be equivalent to Green River formation. Fossils, *Crocodilus, Clastis* and *Priscacara*.

.561 The skull of *Empedocles*. *Amer. Nat.* Vol. XIV, 1880, p. 304.
March Description of the skull of *E. molaris* from Permian of
21 Texas. Now referred to *Diadectes*. Cotylosauria proposed as a suborder of Theromorpha to include *Diadectes*.

.562 A New Genus of Tapiroids. *Amer. Nat.* Vol. XIV, 1880, pp.
April 382, 383.
27 *Triplopus cubitalis* gen. et sp. nov. from Eocene of Washakie basin of Wyoming.

.563 The Structure of the Permian Ganocephala. *Amer. Nat.*
April Vol. XIV, 1880, pp. 383, 384.
27 Characters of vertebræ scapular and pelvic arches in *Eryops*.

.564 [Statements concerning the election of officers for the Phila-
April delphia Academy of Natural Sciences.] *Amer. Nat.* Vol.
27 XIV, 1880, pp. 390, 391.
Unsigned.

.565 May 21 Traquair on *Platysomidæ*. *Amer. Nat.* Vol. XIV, 1880, pp. 439, 440.

Review: On the Structures and Affinities of Platysomidæ, by Ramsay H. Traquair, Trans. Roy. Soc. Edinburgh Vol. XXIX, 1879.

.566 May 21 Corrections of the Geological Maps of Oregon. *Amer. Nat.* Vol. XIV, 1880, pp. 457, 458.

Coast Range formations Tertiary, not Archæan. Sequence of formations in the John Day basin.

.567 June 5 Second Contribution to the History of the Vertebrata of the Permian Formation of Texas. *Proc. Amer. Philos. Soc.* Vol. XIX, 1880, pp. 38-58, Pls. I-VI. *Pal. Bull.* No. 32, pp. 1-22, Pls. I-IV. (The plates were not published until May 2, 1881.) Abstract, *Amer. Nat.* Vol. XIV, 1880, p. 610.

*Ectosteorhachis nitidus* Nov. Gen. et Sp.

.568 June 18 The Geological Record. *Amer. Nat.* Vol. XIV, 1880, pp. 511, 512.

Unsigned. Cited by Hay. Criticism of references to Cope's recent discoveries.

.569 June 21 A New Genus of Rhinocerontidæ. *Amer. Nat.* Vol. XIV, 1880, p. 540.

*Peraceras superciliosus* gen. et sp. nov. described. *Aphelops malacorhinus* referred to this genus. Both from Republican River beds (Pliocene) of Nebraska.

.570 June 23 On certain Tertiary Strata of the Great Basin. *Proc. Amer. Philos. Soc.* Vol. XIX, 1880, pp. 60-62.

.571 July 22 Extinct Batrachia. *Amer. Nat.* Vol. XIV, 1880, pp. 609, 610.

Discoveries of Dr. Anton Fritsch in the Permian "Gaskohle" of Bohemia, and of Dr. Wiedersheim in the "Bunter Sandstein" of Switzerland: discussion of the genus *Cricotus*.

.572 July 22 The Genealogy of the American Rhinoceroses. *Amer. Nat.* Vol. XIV, 1880, pp. 610, 611.

*Triplopus* ancestral to *Aphelops* through *Cænopus* gen. nov. From *Aphelops, Peraceras* leads into African rhinoceroses and *Ceratorhinus* into *Rhinoceros* proper. *Aceratherium* side branch.

.573 Aug. 3 On the Genera of the *Creodonta*. *Proc. Amer. Philos. Soc.* Vol. XIX, 1880, pp. 76-82. Synopsis, *Kosmos,* Vol. X, 1880, pp. 299, 300.

Revised classification and discussion of affinities and phylogeny. The Miacidæ and Mesonychidæ are here included in the order; the former as ancestors of the Canidæ, while the Felidæ are derived from Oxyænidæ. Pp. 76-80 appeared Aug. 3; pp. 81, 82 were printed Sept. 9.

.574 [Government aid to Pure Science.] *Amer. Nat.* Vol. XIV,
Sept. 1880, pp. 654, 655.
Unsigned. Cited by Frazer.

.575 [Biology at the American Association at Boston. Remarks
Sept. on the views of Prof. Barker and Mr. Agassiz concerning
21 Evolution as stated by them before the A. A. A. S. in 1880.]
*Amer. Nat.* Vol. XIV, 1880, pp. 725-728.

.576 The Bad Lands of Wind River and their Fauna. *Amer.*
Sept. *Nat.* Vol. XIV, 1880, pp. 745-748.
21 Notice of Wortman's collections of fossil mammals for
Prof. Cope. Descriptions of *Protopsalis* and *Lambdotherium*
new genera, and ten new species.

.577 [Obligations of Educational and Charitable Institutions.]
Oct. *Amer. Nat.* Vol, XIV, 1880, pp. 793-795.
2 Unsigned. Cited by Frazer.

.578 On the Extinct Cats of America. *Amer. Nat.* Vol. XIV,
Nov. 1880, pp. 833-858, figs. 1-15.
25 Classification and phylogeny; descriptions of White River
and John Day species with figures of the best known John
Day forms, and of *Smilodon necator* from Pampean of South
America.

.579 [The Permanent Exhibition for Philadelphia.] *Amer. Nat.*
Nov. Vol. XIV, 1880, pp. 881, 882.
25 Unsigned. Cited by Frazer.

.580 The Northern Wasatch Fauna. *Amer. Nat.* Vol. XIV,
Nov. 1880, pp. 908, 909.
25 Additional notes on Wind River fauna with descriptions
of two new species.

.581 *Nimravidæ* and Miocene *Canidæ*. *Science* Vol. I, 1880, p. 303.
Dec. Abstract of paper read before the National Academy of
18 Sciences, New York, 1880. See 591.

.582 The United States Geological Survey. *Amer. Nat.* Vol.
Dec. XV, 1881, pp. 39-41.
31 Unsigned. Cited by Frazer.

.583 On the Organization of Academies of Science. *Amer. Nat.*
Dec. Vol. XV, 1881, pp. 41, 42.
31 Unsigned. Cited by Frazer.

.584 A New Genus of Catostomidæ. *Amer. Nat.* Vol. XV.
Dec. 1881, p. 59.
31 *Lipomyzon* from Klamath Lake, Oregon.

.585 The Vertebrata of the Eocene of the Wind River Basin.
Dec. *Amer. Nat.* Vol. XV, 1881, pp. 74, 75.
31 Tenable description of *Bathyopsis fissidens.* Abstract of 592.

1881.586 The Fishes of Pennsylvania. *Report,* (Pennsylvania) *State Commissioner of Fisheries,* 1879-1880, pp. 60-137, Plates I-XXVI.

A systematic and descriptive account of the 157 species then known. It was reprinted in the report for 1881 and 1882, published in 1883.

.587 [The Tariff Laws of the United States.] *Amer. Nat.* Vol.
Jan. XV, 1881, pp. 124-126.
25 Unsigned editorial. Cited by Frazer.

.588 Catalogue of the Vertebrata of the Permian Formation of
Jan. the United States. *Amer. Nat.* Vol. XV, 1881, pp. 162-164.
25 List, with references to publication of 51 species.

.589 On some New Batrachia and Reptilia from the Permian
Feb. Beds of Texas. *Bull. U. S. Geol. and Geogr. Survey of the*
11 *Territories* Vol. VI, No. 1, pp. 79-82.

.590 On a Wading Bird from the Amyzon Shales. *Bull. U. S.*
Feb. *Geol. and Geogr. Survey of the Territories* Vol. VI, No.
11 1, pp. 83-85. Abstract, "A New Fossil Bird," *Amer. Nat.* Vol. XV, 1881, p. 253.

Notice of *Charadrius sheppardianus.*

.591 On the *Nimravidæ* and the *Canidæ* of the Miocene Period.
Feb. *Bull. U. S. Geol. and Geogr. Survey of the Territories* Vol.
11 VI, No. 1, pp. 165-181. See 581.

.592 On the Vertebrata of the Wind River Eocene Beds of Wyoming.
Feb. *Bull. U. S. Geol. and Geogr. Survey of the Territories*
11 Vol. VI, No. 1, pp. 132-202. Abstract, "The Vertebrata of the Eocene of the Wind River Basin", *Amer. Nat.* Vol. XV, 1881, pp. 74, 75. See 585.

*Bathyopsis fissidens* gen. et sp. nov. described in abstract. *Clastis* sp. and *Pappichthys* named from scales and vertebræ. Read by title before the Amer. Philos. Soc. Dec. 3, 1880, but withdrawn for publication by the U. S. Geol. Survey.

.593 [Laws of Nomenclature.] *Amer. Nat.* Vol. XV, 1881, pp.
Feb. 219-221.
24 Unsigned editorial.

.594 Feb. 24 The Japanese Lap Dog. *Amer. Nat.* Vol. XV, 1881, pp. 233, 234.

.595 Feb. 24 Extinct Palæozoic Fishes from Canada. *Amer. Nat.* Vol. XV, 1881, pp. 252, 253.

Notice of article by Whiteaves on discoveries in Devonian of Baie des Chaleurs. Unsigned. Cited by Hay.

.596 Feb. 24 A New Fossil Bird. *Amer. Nat.* Vol. XV, 1881, p. 253.

Notice of Dr. Allen's description of *Palæospiza bella*—Hay, and of *Charadius sheppardianus* from Amyzon beds of Colorado. Type of latter in Amer. Mus.

.597 Feb. 24 Geological News. *Amer. Nat.* Vol. XV, 1881, pp. 254, 340, 413, 1023.

Unsigned notes. Cited by Hay. Brief notes of various papers on vertebrate palæontology. *Stegosaurus*=*Hypsirhophus.*

.598 March 25 On the Origin of the Foot Structures of the Ungulates. *Amer. Nat.* Vol. XV, 1881, pp. 269-273, figs. 1-5.

Explanation of the origin of specialized foot structures of ungulates through kinetogenesis.

.599 March 25 Mammalia of the Lower Eocene Beds. *Amer. Nat.* Vol. XV, 1881, pp. 337, 338.

First descriptions of fossil mammals from the Puerco of New Mexico. *Periptichus carinidens, Deltatherium fundaminis,* new genera and species.

.600 March 25 Filhol on *Proælurus.* *Amer. Nat.* Vol. XV, 1881, pp. 339, 340.

Unsigned. Cited by Frazer. Notice of Filhol's memoir on *P. lemanensis* in Bull. soc. sci. phys. et nat.

.601 March 25 The Classification of the Perissodactyla. *Amer. Nat.* Vol. XV, 1881, p. 340.

Tabular key, taken from Rept. U. S. G. S. Terr. (Tertiary Vertebrata.)

.602 May 14 The Systematic Arrangement of the Order *Perissodactyla.* *Proc. Amer. Philos. Soc.* Vol XIX, 1881, pp. 377-401, figs. 1, 2.

Key to families, geological distribution of genera, characters of each family and key to included genera; descriptions of *Triplopus cubitalis* and *T. amarorum,* pp. 377-386, printed May 14; pp. 387-401, May 16.

.603 Note on the Structure of the Posterior Foot of *Toxodon*.
May *Proc. Amer. Philos. Soc.* Vol. XIX, 1881, pp. 402, 403.
16 *Ann. & Mag. Nat. Hist.*, Ser. 5, Vol. VIII, 1881, pp. 389, 390.
Based upon specimens in the Ameghino collection purchased
by Professor Cope (Cope Pampean Collection, Amer.
Mus. Nat. Hist.). The structure forbids reference to Perissodactyla
or Artiodactyla and suggests Proboscidean affinities.

.604 Miocene Dogs. *Amer. Nat.* Vol. XV, 1881, p. 497.
May Diagnosis of *Oligobonis* new genus, and revision of diagnosis
19 of *Hyænocyon* Cope. Corrections and additions to the
paper in Bull. Geol. and Geogr. Surveys of the Territories
Vol. VI, No. 1, p. 177.

.605 On the Effects of Impacts and Strains on the Feet of Mammalia.
June *Amer. Nat.* Vol. XV, 1881, pp. 542-548, figs. 1-11.
22 Further discussion of the evolution of the foot construction
in various ungulates. Read before the National Academy of
Sciences, April, 1881.

.606 [Description and Iconography in Biology.] *Amer. Nat.* Vol.
June XV, 1881, pp. 548, 549.
22 Analytical descriptions cannot be superseded by pictures.
Editorial.

.607 Primary Object of an Academy of Science. *Amer. Nat.*
June Vol. XV, 1881, p. 549.
22 Research. Teaching is a collateral activity. Unsigned editorial.
Cited by Frazer.

.608 The *Rodentia* of the American Miocene. *Amer. Nat.* Vol.
June XV, 1881, pp. 586, 587.
22 List of 37 species from White River and John Day formations.

.609 A New *Clidastes* from New Jersey. *Amer. Nat.* Vol. XV,
June 1881, pp. 587, 588.
22 Description *C. condon* from a partial skeleton (in Rutgers
College).

.610 [Insanity and Responsibility.] *Amer. Nat.* Vol. XV, 1881,
July pp. 641-643.
27 Unsigned editorial. Cited by Frazer.

.611 The Temporary Dentition of a New Creodont. *Amer. Nat.*
July Vol. XV, 1881, pp. 667-669.
27 *Triisodon quivirensis* gen. et sp. nov. based upon a lower
jaw from the Puerco formation of New Mexico; and *Delatherium*
*absarokæ* (afterwards type of *Didelphodus*) from
Wasatch formation of Bighorn basin, Wyo.

.612 A Laramie Saurian in the Eocene. *Amer. Nat.* Vol. XV,
July 1881, pp. 669, 679.
27 *Champosaurus,* from Puerco formation of New Mexico.

.613 Review of the Rodentia of the Miocene Period of North
Sept. America. *Bull. U. S. Geol. and Geogr. Survey of the Ter-*
19 *ritories* Vol. VI, No. 2, pp. 361-386.

.614 On the Canidæ of the Loup Fork Epoch. *Bull. U. S. Geol.*
Sept. *and Geogr. Survey of the Territories* Vol. VI, No. 2, pp.
19 387-390.

.615 [Criticism of Mr. Barn's Metaphysical Definitions.] *Amer.*
Sept. *Nat.* Vol. XV, 1881, p. 791.
23

.616 Mammalia of the Lowest Eocene. *Amer. Nat.* Vol. XV,
Sept. 1881, pp. 829-831.
23 *Conoryctes, Catathlæus* and *Mioclænus,* new genera, from
the Puerco formation. Abstract of 618.

.617 Geology of the Lake Valley Mining District. *Amer. Nat.*
Sept. Vol. XV, 1881, pp. 831, 832.
23

.618 On some Mammalia of the Lowest Eocene Beds of New
Sept. Mexico. *Proc. Amer. Philos. Soc.* Vol. XIX, 1881, pp.
30 484-495. *Pal. Bull.* No. 33, pp. 484-495.
Descriptions of *Periptychus, Conoryctes, Triisodon, Deltatherium, Catathlæus, Anisonchus, Mioclænus*—13 species of these and other genera. Cope does not at this time appear to have been certain whether this fauna was from his Puerco formation or not. "Their horizon is below the Wasatch and they represent a different fauna from that of those beds." See 616 for first notice.

.619 The Fauna of the Nickajack Cave. (With A. S. Packard,
Oct. Jr.) *Amer. Nat.* Vol. XV, 1881, pp. 877-882.
28

.620 [Rules governing Nomenclature.] *Amer. Nat.* Vol. XV,
Oct. 1881, pp. 883, 884.
28 Unsigned editorial. Cited by Frazer. Rules of Internat. Geol. Congress approved, except as to requirement of figure for valid description of new forms. A description is necessary; but that it should be "clear and adequate" is to demand too much.

.621 A Memoir on the *Loxolophodon* and *Uintatherium,* by Henry
Oct. F. Osborn, Sc. D. *Amer. Nat.* Vol. XV, 1881, p. 888, 2 figs.
28 Unsigned review of "A Memoir upon *Loxolophodon* and *Uintatherium,*" etc. Cited by Frazer.

.622 Eocene Plagiaulacidæ. *Amer. Nat.* Vol. XV, 1881, pp. 921,
Oct. 922.
28 *Ptilodus mediaevus* gen. et sp. nov. described from a tooth
from the Puerco formation of New Mexico.

.623 *Belodon* in New Mexico. *Amer. Nat.* Vol. XV, 1881, pp.
Oct. 922, 923.
28 *Belodon buceros* and *ocolopax* described, the former from
a skull.

.624 [Biology as a Profession.] *Amer. Nat.* Vol. XV, 1881,
Dec. pp. 987-990.
Unsigned editorial. Cited by Frazer.

.625 A New Type of *Perissodactyla*. *Amer. Nat.* Vol. XV, 1881,
Dec. pp. 1017, 1018.
3 Preliminary description of skeleton of *Phenacodus primaevus* from Bighorn basin (Wasatch) of Wyoming. Condylarthra proposed as a suborder of Perissodactyla.

.626 New Genus of *Perissodactyla diplarthra*. *Amer. Nat.* Vol.
Dec. XV, 1881, p. 1018.
3 *Systemodon* based upon specimens from Bighorn Wasatch
(incorrectly) referred to *Hyrocotherium tapirinum*.

.627 Notes on *Creodonta*. *Amer. Nat.* Vol. XV, 1881, pp. 1018-
Dec. 1020.
3 *Pachyæna* = *Mesonyx; Dissacus,* a new genus, based upon
*M. navajovius* of Puerco formation; *Lipodectes* gen. nov.
from same horizon, with two species, *penitrans* and *schidens*.

.628 The Permian Formation of New Mexico. *Amer. Nat.* Vol.
Dec. XV, 1881, pp. 1020, 1021.
3 *Eryops reticulatus* and *Zatrachys apicalis* described; other
Permian genera cited as occurring.

.629 (Legal Insanity.) *Amer. Nat.* Vol. XVI, 1882, pp. 33, 34.
Dec. Editorial.
30

.630 The Oldest Artiodactyle. *Amer. Nat.* Vol. XVI, 1882, p. 71.
Dec. Description of type (jaws, foot, etc.) of *Mioclaenus* (now
30 *Diacodexis*) *brachystomus* from Wasatch of Bighorn basin.

.631 The Characters of the *Tæniodonta*. *Amer. Nat.* Vol. XVI,
Dec. 1882, p. 73.
30 Characters of *Calamodon, Tillotherium* and *Esthonyx* compared.

.632 New Forms of *Coryphodontidæ*. *Amer. Nat.* Vol. XVI,
Dec. 1882, p. 72.
30 Key to genera; two new, *Manteodon* and *Ectacodon*.

.633 An Anthropomorphous Lemur. *Amer. Nat.* Vol. XVI, 1882,
Dec. pp. 73, 74.
30 Notice of cranium of "*Anaptomorphus*" (now *Tetonius*)
*homunculus* from Bighorn Wasatch. "The genus is nearer
the hypothetical lemuroid ancestor of man than any yet discovered."

.634 Recent Extinction of the Mastodon. *Amer. Nat.* Vol. XVI,
Dec. 1882, pp. 74, 75.
30 Unsigned. Cited by Hay. Preservation of bones, fat and
stomach-contents in two Illinois skeletons.

1882.635 [Science and Art.] *Amer. Nat.* Vol. XVI, 1882, pp. 123, 124.
Jan. Unsigned editorial. Cited by Frazer.
25

.636 A New Genus of Tillodonta. *Amer. Nat.* Vol. XVI, 1882,
Jan. pp. 156, 157.
25 Description of *Psittacotherium multifragum* gen. sp. nov.
from Puerco formation of New Mexico.

.637 A great Deposit of Mud and Lava. *Amer. Nat.* Vol. XVI,
Jan. 1882, pp. 157, 158.
25 The Puerco region of N. W. New Mexico.

.638 Invertebrate Fossils from the Lake Valley District, New
Jan. Mexico. *Amer. Nat.* Vol. XVI, 1882, pp. 158, 159.
25 List of Lower Carboniferous fossils, identifications by S.
A. Miller.

.639 Contributions to the History of the Vertebrata of the Lower
Feb. Eocene of Wyoming and New Mexico, made during 1881.
20 *Proc. Amer. Philos. Soc.* Vol. XX, 1881, pp. 139-197; Map
of the Bighorn Basin. *Pal. Bull.* No. 34, pp. 139-197. (Has
no map.) Abstract, *Amer. Journ. Sci.*, Ser. 3, Vol. XXIII,
1882, pp. 324-325.

Descriptions of fossil vertebrate collections made by J. L. Wortman for Cope in the Bighorn Basin during the summer of 1881. The descriptions are somewhat amplified and illustrations provided in "Tertiary Vertebrata," 1884. Includes a classification of the Chelonian families and genera, first description of the Eocene lemuroid "*Anaptomorphus homunculus*" skull; classification of Creodonta and description of various new forms; revision of the Coryphodontidae and description of new species; brief synopsis of characters and species of *Phenacodus;* new species of *Hyracotherium, Systemodon,* etc.; *Mioclaenus brachystomus* sp. nov. an unquestionable artiodactyl. Fauna is typical Wasatch; distinctions from Wind River fauna. Descriptions of a number of new mammals from the "Catathlaeus beds" of New Mexico (Puerco).

.640 Feb. 24 The Tertiary Formations of the Central Region of the United States. *Amer. Nat.* Vol. XVI, 1882, pp. 177-195, figs. 1-8.

Description of the successive Tertiary "lakes," their location and extent, character of the formations and prominent features of the faunae.

.641 Feb. 24 [The Equivalents of Consciousness.] *Amer. Nat.* Vol. XVI, 1882, pp. 224-226.

Review of essay by E. DuBois Raymond, The Seven World Problems, translated in *Pop. Sci. Mo.* Vol. XX, pp. 433-447.

.642 Feb. 24 Marsh on the Classification of the Dinosauria. *Amer. Nat.* Vol. XVI, 1882, pp. 253-255.

Critical Review of Marsh's article in *Amer. Journ. Sci.* (3) Vol. XXIII, pp. 81-86.

.643 Feb. 24 The Dinosaurs of Bernissart. *Amer. Nat.* Vol. XVI, 1882, pp. 255, 256.

Review of articles by G. A. Boulenger and P. J. Van Beneden. *Bull. Acad. R. de Belge,* 1881, Ser. 3, T. I., pp. 600-608. Unsigned review, evidently Cope's. (W. D. M.)

.644 Feb. 24 Hulke on *Polacanthus foxi.* *Amer. Nat.* Vol. XVI, 1882, p. 256.

Notice of description of this English dinosaur by J. M. Hulke in *Trans. R. Soc. London* Vol. 72, Pt. III, 1881, pp. 653-662, Pls. 70-76. Unsigned. Evidently by Cope. (W. D. M.)

.645 Feb. 24 Russian Sauropterygia. *Amer. Nat.* Vol. XVI, 1882, p. 256.

Notice of memoir on Ichthyosaurus by Kiprijanoff in *Mem. Acad. Imper. Sci. St. Petersbourg,* Ser. 7, T. XXVIII, No. 8.

.646 March 22 [Effort and Use in Evolution.] *Amer. Nat.* Vol. XVI, 1882, pp. 311-313. Editorial.

Further discussion of the views of E. DuBois Raymond.

.647 March 22 New Characters of the *Perissodactyla Condylarthra.* *Amer. Nat.* Vol. XVI, 1882, p. 334.

Creodont characters of humerus in *Phenacodus.* *Meniscotherium* referred to this suborder; key to families.

.648 March 22 *Mesonyx* and *Oxyæna.* *Amer. Nat.* Vol. XVI, 1882, p. 334.

Characters of limb bones in *Mesonyx* (now *Pachyaena*) *ossifragus;* of hind foot in *Oxyæna.* Based on Wortman's Bighorn Wasatch collections.

.649 March 22 The Rachitomous Stegocephali. *Amer. Nat.* Vol. XVI, 1882, pp. 334, 335.

Ganocephala not available. Rhachitomi suborder, including *Eryops, Actinodon, Trimerorhachis, Zatrachys,* etc., in two families.

.650 April 24 A Second Genus of Eocene Plagiaulacidæ. *Amer. Nat.* Vol. XVI, 1882, pp. 416, 417.

*Catopsalis foliatus* gen. et sp. nov. described from Puerco of New Mexico.

.651 April 24 Two New Genera of the Puerco Eocene. *Amer. Nat.* Vol. XVI, 1882, pp. 417, 418.

Description of *Haploconus lineatus* and *Pantolambda bathmodon* new genera and species.

.652 May 20 On Archæsthetism. *Amer. Nat.* Vol. XVI, 1882, pp. 454-469.

Discussion of the origin of adaptive changes in phyla; the nature of consciousness and its relations thereto, as a fundamental cause of evolution.

.653 May 20 [Sexual Selection in Man.] *Amer. Nat.* Vol. XVI, 1882, pp. 490-492.

Editorial.

.654 May 20 The Ancestry and Habits of *Thylacoleo.* *Amer. Nat.* Vol. XVI, 1882, pp. 520-522.

Thylacoles, a descendant of the *Plagiaulacidæ.* *Hypriprymus* parallel not nearly related. Probably not herbivorous, perhaps egg-eating or even carnivorous.

.655 May 20 Notes on Eocene Mammalia. *Amer. Nat.* Vol. XVI, 1882, p. 522.

*Didelphodus* and *Ectocion* new genera, Wasatch Eocene Bighorn basin.

.656 May 20 On the *Taxæopoda,* a New Order of *Mammalia.* *Amer. Nat.* Vol. XVI, 1882, pp. 522, 523.

Carpus of *Phenacodus* excludes it from Perissodactyla. The new order includes Condylarthra and Proboscidea. Key to Ungulate orders.

.657 May 20 [Note on *Achænodon insolenus.*] *Amer. Nat.* Vol. XVI, 1882, p. 534.

Notice of discovery of skull by Princeton Expedition.

.658 June 6 On the *Condylarthra.* *Proc. Acad. Nat. Sci. Phila.* Vol. XXXIV, 1882, pp. 95-97. Reprint, *Ann. & Mag. Nat. Hist.,* Ser. 5, Vol. X, 1882, pp. 76-79.

.659 A New Genus of Tæniodonta. *Amer. Nat.* Vol. XVI, 1882,
June pp. 604, 605.
22 *Tæniolabis sulcatus* gen. et sp. nov., based upon an incisor tooth from the Puerco of New Mexico. Unsigned. Cited by Hay and Frazer.

.660 [The Philadelphia Academy of Natural Sciences.] *Amer.*
July *Nat.* Vol. XVI, 1882, pp. 663, 664.
28 Unsigned editorial. Cited by Frazer.

.661 New Marsupials from the Puerco Eocene. *Amer. Nat.*
July Vol. XVI, 1882, pp. 684-686.
28 Descriptions of *Polymastodon taöensis* and *Catopsalis pollux* new genera and species. (These subsequently proved to be founded upon the upper and lower dentition of the same individual. Both are probably identical with *Taeniolabis sulcatus.*) New species of *Ptilodus* and *Haploconus* also described; all from Puerco formation of New Mexico.

.662 [Projects for Commemorating Men of Science.] *Amer. Nat.*
Sept. Vol. XVI, 1882, pp. 803, 804.
28 Unsigned editorial. Cited by Frazer.

.663 Mammalia in the Laramie Formation. *Amer. Nat.* Vol.
Sept. XVI, 1882, pp. 830, 831.
28 Description of *Meniscœssus conquistus* gen. et sp. nov. (from the Lance formation).

.664 A New Form of Tæniodonta. *Amer. Nat.* Vol. XVI, 1882,
Sept. pp. 831, 832.
28 *Hemiganus vultuosus* (=*Psittacotherium*) from Puerco of New Mexico.

.665 The *Periptychidæ*. *Amer. Nat.* Vol. XVI, 1882, pp. 832, 833.
Sept. Structure of brain and foot, etc., in *Periptychus;* descrip-
28 tion of *Hemithlæus kowalevskianus* gen. et sp. nov., etc.

.666 Some New Forms from the Puerco Eocene. *Amer. Nat.*
Sept. Vol. XVI, 1882, pp. 833, 834.
28 New species of *Mioclænus, Protogonia* and *Dissacus*.

.667 [Remarks on Guiteau's Brain.] *Amer. Nat.* Vol. XVI, 1882,
Oct. pp. 895, 896.
28 Unsigned editorial. Cited by Frazer.

.668 [Note on the Bite of a Gila Monster.] *Amer. Nat.* Vol.
Oct. XVI, 1882, pp. 908, 909.
28

.669 The Recent Discoveries of Fossil Footprints in Carson,
Oct. Nevada. *Amer. Nat.* Vol. XVI, 1882, pp. 921-923.
28 Unsigned. Cited by Hay. Notice of paper by Le Conte read before the California Academy of Sciences.

.670 Oct. 28 Geological News. *Amer. Nat.* Vol. XVI, 1882, pp. 925, 926.

Brief notices of papers by Scudder, *Amer. Journ. Sci.* (3) Vol. XXIV, pp. 161-170; McGee and Call, Ibid, pp. 202-223; Scott and Osborn, Ibid, pp. 223-225. Unsigned. Cited by Hay.

.671 Nov. 11 The Classification of the Ungulate Mammalia. *Proc. Amer. Philos. Soc.* Vol. XX, 1882, pp. 438-447. *Pal. Bull.* No. 35, pp. 438-447. Abstract, *Science* Vol. I, 1883, p. 182.

Construction of carpus and tarsus is fundamental to the ordinal classification. Relations of carpals and tarsals in different groups of ungulates; key to orders; phylogeny.

.672 Nov. 11 Third Contribution to the History of the Vertebrata of the Permian Formation of Texas. *Proc. Amer. Philos. Soc.* Vol. XX, 1882, pp. 447-461. *Pal. Bull.* No. 35, pp. 447-461. Abstract, "Permian Vertebrata," *Amer. Nat.* Vol. XVI, 1882, p. 925.

Descriptions of *Edaphosaurus, Ectocynodon, Diplocaulus, Acheloma, Anisodexis,* the first and last two new genera.

.673 Nov. 11 Synopsis of the Vertebrata of the Puerco Eocene Epoch. *Proc. Amer. Philos. Soc.* Vol. XX, 1882, pp. 461-471. *Pal. Bull.* No. 35, pp. 461-471.

List of vertebrata, chiefly mammals; descriptions of a number of new species; relations of the fauna.

.674 Nov. 11 On the Systematic Relations of the *Carnivora* Fissipedia. *Proc. Amer. Philos. Soc.* Vol. XX, 1882, pp. 471-475. *Pal. Bull.* No. 35, pp. 471-475. Reprint, *Ann. & Mag. Nat. Hist.*, Ser. 5 Vol. XII, 1883, pp. 112-116.

Classification, based primarily upon the turbinal bones, then upon teeth, alisphenoid, etc.; list of genera of each family. *Plethælurus* gen. nov. for *Felis planiceps.*

.675 Dec. 2 The Reptiles of the American Eocene. *Amer. Nat.* Vol. XVI, 1882, pp. 979-993, figs. 11-13.

Review of Eocene reptilian fauna; figures of *Palaeophis* vertebræ; skulls of 3 species of Crocodiles, several turtles.

.676 Dec. 2 [Women in Universities.] *Amer. Nat.* Vol. XVI, 1882, pp. 994, 995.

Unsigned editorial. Cited by Frazer.

.677 Dec. 2 Two New Genera of Mammalia from the Wasatch Eocene. *Amer. Nat.* Vol. XVI, 1882, p. 1029.

*Diacodexis* and *Heptodon,* new genera, from the Bighorn basin.

.678 Restoration of *Loxolophodon cornutus* Cope, one-twentieth
Dec. natural size. From the Bridger Eocene of Wyoming. *Amer.*
2 *Nat.* Vol. XVI, 1882, Pl. XVII (no text).
Reduced from drawing afterwards published in "Tertiary Vertebrata."

1883.679 On the contents of a Bone Cave in the Island of Anguilla (West Indies). *Smithsonian Contrib. to Knowledge* Vol. XXV, Art. 3, pp. 1-34, Pls. I-V. Separates 1883.
Extended description and illustrations of *Amblyrhiza*, etc.

.680 The Classification of the Ungulata. *Proc. A. A. A. S.* XXXI Meeting, 1882, pp. 477-479.

.681 The Fauna of the Puerco Eocene. *Proc. A. A. A. S.* XXXI Meeting, 1882, pp. 479, 480.

.682 The Nevada Biped Tracks. *Amer. Nat.* Vol. XVII, 1883,
Jan. pp. 69, 70, three figures.
5 Remarks with figures from Harkness' paper before Calif. Acad. Sci. Supposed to be a reprint of 689, but in reality appearing first. The cuts are not in the Proc. Acad. Nat. Sci. Phila.

.683 On *Uintatherium* and *Bathmodon*. *Amer. Nat.* Vol. XVII,
Jan. 1883, p. 68.
5 Distinctions in incisors between *Uintatherium* and *Bathyopsis;* in astragalus between *Coryphodon* and *Bathmodon*. Intended as an abstract of 690.

.684 The Extinct Rodentia of North America. *Amer. Nat.* Vol.
Jan. XVII, 1883, pp. 43-57; 165-174; 370-381; figs. 1-30.
5 Key to classification, geological distribution, review of genera and species with figures of many specimens from Wasatch and Bridger, White River and John Day; afterwards published in extenso in "Tertiary Vertebrata." The groups of pages appeared successively on January 5th and 31st, and March 15.

.685 [The National Academy of Sciences.] *Amer. Nat.* Vol.
Jan. XVII, 1883, pp. 59, 60.
5 Unsigned editorial. Cited by Frazer.

.686 Kowalevsky on *Elasmotherium*. *Amer. Nat.* Vol. XVII,
Jan. 1883, p. 72.
5 Notice of Kowalevsky's memoir.

.687 Two New Genera of Pythonomorpha. *Amer. Nat.* Vol.
Jan. XVII, 1883, pp. 72, 73.
5 Comment on Dollo's paper, "Note sur l'osteologie des

Mosasauridæ," Bull. Mus. Roy. d'hist. nat. de Belgique, T. I., pp. 1-20, Pls. IV, V et VI.

.688 Scudder on Triassaic Insects. *Amer. Nat.* Vol. XVII, 1883,
Jan. p. 73.
5 Note on the age of the Red Beds near Fairplay, Colorado.

.689 (Contemporaneity of Man and Pliocene Mammals). *Proc.*
Jan. *Acad. Nat. Sci., Phila.* Vol. XXXIV, 1882, pp. 291, 292.
16 See also 682 and note. Later discussion 746.

.690 On *Uintatherium*, *Bathmodon* and *Triisodon*. *Proc. Acad.*
Jan. *Nat. Sci Phila.* Vol. XXXIV, 1882, pp. 294-300.
16 For abstract see 683 and note.

.691 (The Beastiarians). *Amer. Nat.* Vol. XVII, 1883, p. 175.
Jan. Criticism of antivivisectionist activities. Unsigned editorial.
31 Cited by Frazer.

.692 Filhol's Fossil Mammals of Ronzon. *Amer. Nat.* Vol. XVII,
Jan. 1883, pp. 190, 191.
31 Review of "Etude des Mammiferes fossiles de Ronzon
(Haute Loire)," by M. H. Filhol.

.693 New Mammalia from the Puerco Eocene. *Amer. Nat.*
Jan. Vol. XVII, 1883, p. 191.
31 *Helagras prisciformis* gen. et sp. nov.; *Pantolestes* provisionally placed in Artiodactyla with species "*Mioclaenus*" *brachystomus* and *etsagicus* referred to it. No other tenable description of new forms. Abstract of 695.

.694 Zoölogical Geography of Western North America. *Science*
Feb. Vol. I, No. 1, February 9, 1883, p. 21.
9 Abstract of 697.

.695 First Addition to the Fauna of the Puerco Eocene. *Proc.*
Feb. *Amer. Philos. Soc.* Vol. XX, 1883, pp. 545-563. *Pal. Bull.*
14 No. 36, pp. 545-563.

In the full paper appears an extended description of "*Mioclænus*" *ferox* (= *Clænodon*), compared here with carnivorous marsupials (a view subsequently withdrawn by Professor Cope); of skeleton of *Pantolambda* for which a new suborder of Amblypoda, Taligrada, is erected; of various new species, etc.; the Puerco mammals nearly all have tritubercular molars, quadritubercular molar derived from this type. For description of *Pantolambda* see 702 and note. Also see note on dates of publication of the various pages of this article. In the Proc. Amer. Philos. Soc., pp. 545-554 were printed February 14, 555-563 on March 16. Bull. published April 17. For abstract see 693.

.696 Phylogeny of the Sirenia. *Science* Vol. I, No. 2, February
Feb. 16, 1883, p. 53.
16 Abstract of 706.

.697 Notes on the Geographical Distribution of Batrachia and
Feb. Reptilia in Western North America. *Proc. Acad. Nat. Sci.*
20 *Phila.* Vol. XXXV, 1883, pp. 10-35.
See 694.

.698 On the Extinct Dogs of North America. *Amer. Nat.* Vol.
Feb. XVII, 1883, pp. 235-249, figs. 1-14.
21 Key to extinct American genera; descriptions with figures of principal forms from John Day and Loup Fork (some figures afterwards in "Tertiary Vertebrata," others in "Unpublished Plates of Tertiary Vertebrata"). Phylogeny and origin.

.699 [Credit and Appropriation.] *Amer. Nat.* Vol. XVII, 1883,
Feb. pp. 293, 294.
21 Unsigned editorial. Cited by Frazer.

.700 A New Fossil Sirenian. *Amer. Nat.* Vol. XVII, 1883, p. 309.
Feb. *Dioplotherium manigaulti* nov. gen. et sp. from Miocene
21 of S. Carolina. Abstract of 706 as is also 696.

.701 Lydekker on Indian Mammalia. *Amer. Nat.* Vol. XVII,
March 1883, pp. 405, 406.
15 Critical review of *Pal. Indica,* Vol. III, Pts. I and III.

.702 The Ancestor of *Coryphodon.* *Amer. Nat.* Vol. XVII, 1883,
March pp. 406, 407.
15 Skeleton characters of *Pantolambda;* referred to Amblypoda new suborder; Taligrada, family Pantolambdidæ. Antedates by one day the pages of 695 dealing with this genus.

.703 On the Brains of the Eocene Mammalia *Phenacodus* and
March *Periptychus.* *Proc. Amer. Philos. Soc.* Vol. XX, 1883, pp.
16 563-565, Pls. I, II. *Pal. Bull.* No. 36, pp. 563-565, Pls. I, II.
In *Phenacodus* cerebrum remarkably small; sylvian fissure and traces of 3 convolutions present; cerebellum with distinct vermis and large lateral lobes. Olfactory lobes large, well separated. In *Periptychus* olfactory lobes enormous, mesencephalon wholly exposed, no sylvian fissure.

.704 *Dimodipsas,* a New Venomous Snake. *Science* Vol. I, No. 7,
March March 23, 1883, p. 204.
23 From South America. See 710.

.705 Permian Fishes and Reptiles from Texas. *Science* Vol. I,
March No. 7, March 23, 1883, p. 204.
23 Supposed to be a reprint of Proc. Acad. Nat. Sci. Phila., but in reality published first. See 711.

.706 March 27 On a New Extinct Genus of Sirenia from South Carolina. *Proc. Acad. Nat. Sci. Phila.* Vol. XXXV, 1883, pp. 52-54.

For abstract see 696 and 700.

.707 March 27 The Tritubercular Type of Superior Molar Tooth. *Proc. Acad. Nat. Sci. Phila.* Vol. XXXV, 1883, p. 56. Reprinted, "Note on the Trituberculate Type of Superior Molar and the Origin of the Quadrituberculate," *Amer. Nat.* Vol. XVII, 1883, pp. 407, 408.

The quadritubercular molar type derived from it. Predominant in Puerco Eocene.

.708 March 30 Permian Reptiles. *Science* Vol. I, No. 8, March 30, 1883, p. 232.

Supposed to be a verbal communication at the Acad. Nat. Sci. Phila., March 13, 1883, but not to be found in the Proceedings.

.709 April 4 Fourth Contribution to the History of the Permian Formation of Texas. *Proc. Amer. Philos. Soc.* Vol. XX, 1883, pp. 628-636. *Pal. Bull.* No. 36, pp. 628-636.

*Ectosteorhachis, Gnathorhija* gen. nov., *Chilonyx* gen. nov., and new species of *Empedias: Pariotichus megalops. Pariotichus-Pantylus-Ectocynodon* = new family *Pariotichidæ.*

.710 April 10 On *Dinodipsas* and *Causus. Proc. Acad. Nat. Sci. Phila.* Vol. XXXV, 1883, p. 57.

For abstract see 704.

.711 April 10 Permian Fishes and Reptiles. *Proc. Acad. Nat. Sci. Phila.* Vol. XXXV, 1883, p. 69. Abstract, *Amer. Nat.* Vol. XVII, 1883, p. 905.

See also 705.

.712 April 18 [Scientific Publications of the United States Government.] *Amer. Nat.* Vol. XVII, 1883, pp. 515, 516.

Unsigned editorial. Cited by Frazer.

.713 April 18 The Genus *Phenacodus. Amer. Nat.* Vol. XVII, 1883, p. 535, Pl. XII.

General characters, with figure, of skeleton found by Wortman in Bighorn basin of Wyoming; list of species of the genus.

.714 May 4 Geology of Brazil. *Science* Vol. I, No. 13, May 4, 1883, pp. 367, 368.

This is supposed to be part of the Proc. Acad. Nat. Sci. Phila. for April 10, but is not in the volume for 1883.

.715 May 4 The bunotherian Mammalia. *Science* Vol. I, No. 13, May 4, 1883, p. 372.

An abstract of 718 but first to be printed.

.716 The Developmental Significance of Human Physiography.
May *Amer. Nat.* Vol. XVII, 1883, pp. 618-627, Pls. XIII-XV,
17 figs. 1-9.

.717 [The National Academy of Sciences.] *Amer. Nat.* Vol.
May XVII, 1883, pp. 627, 628.
17 Unsigned editorial.

.718 On the Mutual Relations of the Bunotherian Mammalia.
May *Proc. Acad. Nat. Sci. Phila.* Vol. XXXV, 1883, pp. 77-83.
22 Reprint, *Ann. & Mag. Hist.*, Ser. 5, Vol. XII, 1883, pp. 20-26.
For abstract see 715.

.719 Characters of the Hadrosauridæ. *Science* Vol. I, No. 16,
May May 25, 1883, p. 468.
25 Intended as an abstract of 721 but printed first.

.720 On a New Extinct Genus and Species of Percidæ from
June Dakota Territory. *Amer. Journ. Sci.* Ser. 3, Vol. XXV,
1883, pp. 414-416.
*Plioparchus* Nov. Gen., and *P. whitei and P. sexspinosus* N. Sp.

.721 On the Characters of the Skull of the Hadrosauridæ. *Proc.*
June *Acad. Nat. Sci. Phila.* Vol. XXXV, 1883, pp. 97-107, Pls.
5 IV-VII. Abstract, "The Structure and Appearance of a Laramie Dinosaurian." *Amer. Nat.* Vol. XVII, 1883, pp. 774-777, Pls. XVI-XIX, & pp. 1000, 1001.
See also 719.

.722 The Unification of Geological Nomenclature and Cartog-
June raphy. *Amer. Nat.* Vol. XVII, 1883, pp. 764, 765.
20 Unsigned editorial. Cited by Frazer.

.723 On some Vertebrata from the Permian of Illinois. *Proc.*
June *Acad. Nat. Sci. Phila.* Vol. XXXV, 1883, pp. 108-110.
26 *Thoracodus emydinus* Nov. Gen. et Sp., and *Ctenodus heterolophus* and *C. vasabinsis* N. Sp.

.724 Puerco Beds in France. *Science* Vol. II, No. 22, July 6,
July 1883, p. 20.
6 Supposed to be a verbal communication at the Academy of

.725 A New Hydroid Polyp. *Science* Vol. II, No. 22, July 6,
July 1883, p. 22.
6 In reality one paragraph of 732, p. 140. It appeared before the entire article, however.

.726 Extinct fauna of Idaho and Oregon. *Science* Vol. II, No.
July 23, July 13, 1883, p. 56.
13 An abstract of 732 but published before the article.

.727 Late Works on Evolution. *Amer. Nat.* Vol. XVII, 1883,
July pp. 855-858.
16 Review of: The Theories of Darwin and Their Relation to Philosophy, Religion and Morality, by Rudolf Schmid; Final Causes, by Paul Janet; A Critique of Design-arguments, etc., by L. E. Hicks; Development, what it can do and what it cannot do, by James McCosh; Natural Selection and Natural Theology, a discussion between Dr. Romanes and Dr. Asa Gray, *Nature* Vol. XXVI, 1883.

.728 A New Pliocene Formation in the Snake River Valley.
July *Amer. Nat.* Vol. XVII, 1883, pp. 867, 868.
16 Willow Creek, in Eastern Oregon.

.729 The "Third Trochanter" of the Dinosaurs. *Amer. Nat.* Vol.
July XVII, 1883, p. 869.
16 Unsigned. Cited by Hay. A summary of Dollo's article in *Bull. Mus. R. Hist. Nat. Belg.* T. I. Mars, pp. 13-18, Pl. I.

.730 The Puerco Fauna in France. *Amer. Nat.* Vol. XVII, 1883,
July pp. 869, 870.
16 A critical summary of Lemoine's "Recherches sur les oisseaux fossils des terrains tertiares inférieurs des environs de Reims." Part II. For abstract see 724.

.731 The Fishes of the Batsto River, New Jersey. *Proc. Acad.*
July *Nat. Sci. Phila.* Vol. XXXV, 1883, pp. 132, 133. Abstract,
24 *Science* Vol. II, No. 26, p. 149.

Eleven species listed and *Amiurus prosthistius* N. Sp. described.

.732 On the Fishes of the Recent and Pliocene Lakes of the
Aug. Western Part of the Great Basin, and of the Idaho Pliocene
7 Lake. *Proc. Acad. Nat. Sci. Phila.* Vol. XXXV, 1883, pp. 134-166 and Map. Abstract, "Fossil Fishes from Idaho," *Amer. Nat.* Vol. XVII, 1883, p. 1321.

Faunal list with descriptions of fishes of this region including descriptions of 6 new species of recent fishes and 9 new species out of 22 fossil forms. For an earlier published abstract see 725 and 726.

.733 The Evolutionary Significance of Human Character. *Amer.*
Aug. *Nat.* Vol. XVII, 1883, pp. 907-919.
15 A continuation of 716.

.871 Jordan's Catalogue of Fishes of North America. *Amer. Nat.*
Aug. XVII, 1883, p. 967.
15 Review of anniversary address to the Geol. Soc. London. Unsigned. Given on Dr. Matthew's authority.

.735 Aug. 15 Some New Mammalia of the Puerco Formation. *Amer. Nat.* Vol. XVII, 1883, p. 968.

Additional remains of *Periptychus ditrigonus* show that it belongs to *Conoryctes,* probably family Periptychidæ. Three new species named, genus *Zetodon* (new) defined. Unsigned. Given on Dr. Matthew's authority. See 741.

.736 Aug. 15 Geological Notes. *Amer. Nat.* Vol. XVII, 1883, pp. 968, 970.

Notices of various new publications chiefly on vertebrate palaeontology. Unsigned. Cited by Hay.

.737 Aug. 31 The Evidence for Evolution in the History of the Extinct Mammalia. *Science* Vol. II, 1883, pp. 272-279. Reprint, *Nature* Vol. XXIX, 1884, pp. 227-230; 248-250. Reprint, *Proc. A. A. A. S.,* XXXII Meeting, 1883, pp. 32-48. Abstract, "Progress of the Ungulates in Tertiary Time," *Amer. Nat.* Vol. XVII, 1883, pp. 1055-1057.

The paper was originally read before the A. A. A. S. but not printed in the proceedings (see the second reprint) until 1884.

.738 Sept. The Structure of the Skull in *Diclonius mirabilis,* a Laramie Dinosaurian. *Science* Vol. II, 1883, p. 338. *Proc. A. A. A. S.,* XXXII Meeting, 1883, pp. 315, 316.

Abstract only of paper read before the A. A. A. S. For other papers on *Diclonius* see 719, 721.

.739 Sept. 7 Two primitive Types of Ungulata. *Science* Vol. II, 1883, p. 338. Abstract, "On two primitive types of Ungulatæ," *Proc. A. A. A. S.,* XXXII Meeting, 1883, p. 316.

Abstracts of a paper read before the A. A. A. S. but not printed in the proceedings until 1884.

.740 Sept. 7 The Trituberculate Type of Superior Molar, and the Origin of the Quadrituberculate. *Science* Vol. II, 1883, September 7, p. 338.

Abstract of 760. See also 707.

.741 Sept. 18 On some Fossils of the Puerco Formation. *Proc. Acad. Nat. Sci. Phila.* Vol. XXXV, 1883, pp. 168-170. Abstract, "Some New Mammalia of the Puerco Formation," *Amer. Nat.* Vol. XVII, 1883, p. 968.

See 735. Probably an abstract.

.742 Oct. Weismann's Studies in the Theory of Descent. *Amer. Nat.* Vol. XVII, 1883, pp. 1042-1046.

Unsigned. Cited by Frazer. Review of: Studies in the Theory of Descent, by Dr. August Weismann. Translated and edited, with notes by Raphael Meldola, etc.

.743 Geological Notes. *Amer. Nat.* Vol. XVII, 1883, pp. 1057,
Oct. 1058.
Notices of various papers chiefly on vertebrate palaeontology. Unsigned. Cited on Dr. Matthew's authority.

.744 [The Work of the Mutual Autopical Society.] *Amer. Nat.*
Oct. Vol. XVII, 1883, pp. 1138, 1139.
19 Unsigned editorial. Cited by Frazer.

.745 A new Chrondrostean from the Eocene. *Amer. Nat.* Vol.
Oct. XVII, 1883, pp. 1152, 1153.
19 *Crassopholis magnicaudatus* gen. et sp. nov. from Green River formation of Wyoming.

.746 The Carson Footprints. *Amer. Nat.* Vol. XVII, 1883, p.
Oct. 1153.
19 For earlier discussions see 682 and 689.

.747 Letter from Little Missouri, Dakota. *Proc. Amer. Philos.*
Oct. *Soc.* Vol. XXI, 1883, pp. 216, 217. Reprinted, *Pal. Bull.* No.
30 37, pp. 216, 217, as "On a New Basin of White River Age in Dakota."
Geological notes, list of species of fossil vertebrates.

.748 [Government Aid to Science.] *Amer. Nat.* Vol. XVII,
Nov. 1883, pp. 1258, 1259.
28 Unsigned editorial.

.749 A New Snake from Mexico. *Amer. Nat.* Vol. XVII, 1883,
Nov. pp. 1300, 1301.
28 *Atomarchus multimaculatus.*

.750 The Laramie Formation. *Amer. Nat.* Vol. XVII, 1883, p.
Nov. 1320.
28 Supposedly an abstract of the meeting of the Acad. Nat. Sci. Phila. on June 12. No such communication by Cope is recorded in the proceedings.

.751 The Batrachia of the Permian Period of North America.
Dec. *Amer. Nat.* Vol. XVIII, 1884, pp. 26-39, Pls. II-V, figs. 1-7.
29 Classification, phylogeny of the groups, review of principal American Permian genera with illustrations; discussion of vertebral construction.

.752 Mechanical Evolution. *Amer. Nat.* Vol. XVII, 1884, pp.
Dec. 40, 41.
29 Editorial on Darwin's "Origin of Species."

.753 The Loup Fork Beds on the Gila River. *Amer. Nat.* Vol.
Dec. XVIII, 1884, pp. 58, 59.
29 Abstract of 758. Description of the formation. Age determined by a skull of *Aphelops fossiger* Cope.

.754 Dec. 29 On New Lemuroids from the Puerco Formation. *Amer. Nat.* Vol. XVIII, 1884, pp. 59-62.

Key to classification. *Tricentes* and *Indrodon* new genera described.

1884.755 The Vertebrata of the Tertiary Formations of the West. Book I. *Report, U. S. Geol. Survey of the Territories* (Hayden). Vol. III, pp. i-xxxv, 1-1009, Pls. I-LXXVa.

This volume contains only the first half of Cope's final report to the Hayden Survey upon the Tertiary Mammalia. It includes the Eocene faunas and a part of the Oligocene (Lower Miocene) Rodentia and Insectivora, etc., Carnivora. The second half, to include the Oligocene ("Lower Miocene") Ungulata and the Miocene ("Loup Fork") fauna, was never published, although a large part of the plates were made and printed. (See 1395.) Forty-two fishes are described, belonging to eleven genera, and are shown in 185 figures on 14 plates.

.756 An Account of the Mammalian Fauna of the Post-pliocene Deposits in the State of Indiana. (With J. L. Wortman.) *Fourteenth Ann. Report* (Dept. Geol. and Nat. Hist.), *Survey of Indiana,* John Collet, State Geologist, Pt. II, Palaeontology, 1884, pp. 1-41, Pls. I-VI.

.757 Genus *Equus. Fourteenth Ann. Report* (Dept. Geol. and Nat. Hist.), *Survey of Indiana,* John Collet, State Geologist, Pt. II, Palaeontology, 1884, pp. 40, 41. Appendix to 756.

.758 Jan. 2 On the Distribution of the Loup Fork Formation in New Mexico. *Proc. Amer. Philos. Soc.* Vol. XXI, 1883, pp. 308, 309. *Pal. Bull.* No. 37, pp. 308, 309.

For abstract see 753. Headwaters of Gila R. and San Francisco about 500 feet thickness. Also probably along eastern base of Magdalena mountains.

.759 Jan. 2 Second Addition to the Knowledge of the Puerco Epoch. *Proc. Amer. Philos. Soc.* Vol. XXI, 1883, pp. 309-324. *Pal. Bull.* No. 37, pp. 309-324.

Several new species described; extended description of *Tricentes* and *Indrodon; Chirox* described as new genus; synopsis of the Eocene lemuroid genera; characters of the fauna—tritubercular bunodont teeth and plantigrade pentadactyl feet.

.760 Jan. 2 On the Trituberculate Type of Molar Tooth in the Mammalia. *Proc. Amer. Philos. Soc.* Vol. XXI, 1883, pp. 324-326. *Pal. Bull.* No. 37, pp. 324-326. *Proc. A. A. A. S.* XXXII Meeting, 1883, pp. 313-315.

Viewed as the primitive type from which are derived the later types of mammalian molars. Of these papers the Pal. Bull. was the first to be issued, its pagination being, as usual, that of the Philos. Soc. Both these differ in only the minutest detail from the Proc. A. A. A. S., so that it seems inadvisable to regard that, published in 1884 also as a separate article. For abstract see 740.

.761 [The Society of Naturalists of the Eastern United States.]
Jan. *Amer. Nat.* Vol. XVIII, 1884, pp. 160, 161.
21 Unsigned editorial. Cited by Frazer.

.762 Mission Scientifique au Mexique; Recherches zoologiques;
Jan. Trois. Partie, Rech. sur les Reptiles et les Batrachiens, par
21 MM. Duméril et Bocourt. *Amer. Nat.* Vol. XVIII, 1884, pp. 162, 163.
Review.

.763 Results of the Deep-sea Work of the "Talisman." *Amer.*
Jan. *Nat.* Vol. XXVIII, 1884, p. 177.
21

.764 On Extinct Rhinoceri from the Southwest. *Proc. Acad.*
Jan. *Nat. Sci. Phila.* Vol. XXXV, 1883, p. 301.
29

.765 The History of the Oreodontidæ. *Amer. Nat.* Vol. XVIII,
Feb. 1884, pp. 280-282.
17 Abstract of 786, printed before the article. Review of the genera and list of species with phyletic relations and geologic occurrence.

.766 The Creodonta. *Amer. Nat.* Vol. XVIII, 1884, pp. 255-267;
Feb. 344-353; 478-485, figs. 1-30.
17 Affinities, classification, review of principal known genera with illustrations. The discussion of the affinities of the Creodonta with Marsupials, Insectivora, etc., is an admirable example of sound reasoning in comparative anatomy, and of clear and condensed presentation of the salient points of the evidence then available. The pages appeared successively in the March (published Feb. 17), April (published March 15), and May (published April 19) numbers of the Amer. Nat.

.767 [The Law and Insanity.] *Amer. Nat.* Vol. XVIII, 1884,
Feb. pp. 267-269.
17 Editorial.

.768 Professor Owen on Fossil Mammals. *Amer. Nat.* Vol.
Feb. XVIII, 1884, p. 283.
17 Unsigned but in the index of the volume under Cope. Notice of Owen's descriptions of *Sceparnodon* from the Pleis-

tocene of Australia (*Philos. Trans.*, Pt. 1, pp. 245-248, Pl. 12), and *Tritylodon* from the Trias of South Africa (*Quart. Journ. Geol. Soc.*, London, Vol. XL, pp. 146-156, Pl. VI). The latter is allied to *Meniscoëssus* and *Polymastodon*.

.769 Filhol on Eocene Lemuroids. *Amer. Nat.* Vol. XVIII, 1884,
Feb. p. 283.
17 Note upon supposed identity of *Anaptomorphus* with *Necrolemur* and of *Notharctus* with *Adapis*. Filhol's paper, *Ann. Sci. géol.* Vol. 14.

.770 The Diseases of the Will. *Amer. Nat.* Vol. XVIII, 1884,
Feb. pp. 317, 318.
17 Review of: Diseases of the Will, by Th. Ribot; Humboldt Library No. 52.

.771 A Carboniferous Genus of Sharks still living. *Science* Vol.
March III, No. 57, March 7, 1884, pp. 275, 276.
7 *Chlamydoselachus-Didymodus*. See also 773, 782 and 792.

.772 [Natural Science in Philadelphia.] *Amer. Nat.* Vol.
March XVIII, 1884, pp. 393-395.
15 Unsigned editorial. Cited by Frazer.

.773 The Skull of a Still Living Shark of the Coal Measures.
March *Amer. Nat.* Vol XVIII, 1884, pp. 412, 413.
15 See 771 for the first note on *Didymodus*.

.774 Philadelphia Academy. *Amer. Nat.* Vol. XVIII, 1884, pp.
April 510, 511.
19 Unsigned editorial. Under Cope in volume index.

.775 Garman's North American Reptiles and Batrachians. *Amer.*
April *Nat.* Vol. XVIII, 1884, pp. 513-515.
19 Review of: A List of the Species occurring North of the Isthmus of Tehuantepec, with references. From the Bulletin, Essex Institute, Salem, Jan. 1884. On the Reptiles and Batrachians [of the Kentucky Geological Survey]. From Memoirs, Museum of Comparative Zoölogy, Cambridge, 4to. (no date). Unsigned. Cited by Frazer.

.776 The Mastodons of North America. *Amer. Nat.* Vol. XVIII,
April 1884, pp. 524-526. Abstract ("Different Species of Masto-
19 dons,") *Science* Vol. III, No. 65, May 2, 1884, pp. 553, 554.
Key to the American species; description of new forms. The abstract is supposed to be a verbal communication before the Acad. Nat. Sci. Phila., March 22, but is not recorded in the Proceedings.

.777 Marsh on Diplodocus. *Amer. Nat.* Vol. XVIII, 1884,
April p. 526.
19 Critical notice of Marsh's paper in *Amer. Journ. Sci.*

.778 The Pelvisternum of Edentates. *Amer. Nat.* Vol. XVIII,
May 1884, pp. 639, 640.
17 Review of Albrecht's paper. Unsigned. Cited by Hay.

.779 The Practical Type of Mind. *Amer. Nat.* Vol. XVIII,
May 1884, p. 644.
17

.780 The Tertiary Marsupialia. *Amer. Nat.* Vol. XVIII, 1884,
May pp. 686-697, figs. 1-9.
17 Didelphidæ and Multituberculata. Classification of Multituberculates, description of principal forms with illustrations; phylogeny.

.781 [Note on the Collections in the Muséo Nacional.] *Proc.*
May *Amer. Philos. Soc.* Vol. XXI, 1884, p. 487.
29

.782 *Pleuracanthus* and *Didymodus.* *Science* Vol. III, No. 69,
May May 30, 1884, pp. 645, 646.
30 See also 771 and 792.

.783 [Zoology in the National Parks.] *Amer. Nat.* Vol. XVIII,
June 1884. pp. 708, 709.
17 Unsigned editorial. Cited by Frazer.

.784 Lydekker on Extinct Mammalia of India. *Amer. Nat.* Vol.
June XVIII, 1884, pp. 717, 718.
17 Critical review of: Memoirs, Geological Survey of India, Ser. X, Vol. II, Siwalik Camelopardalidæ, and Siwalik and Narbada Carnivora (Parts IV and VI); Vol. III Additional Perissodactyla and Proboscidia (Part I).

.785 Notes on Abnormal Deer Antlers. *Amer. Nat.* Vol. XVIII,
June 1884, pp. 737, 738.
17 Editorial note on communication by J. D. Caton.

.786 Synopsis of the Species of Oreodontidæ. *Proc. Amer. Philos.*
July *Soc.* Vol. XXI, 1884, pp. 503-572, two figs. *Pal. Bull.* No. 38,
1 pp. 503-572, two figs.
Synopsis of family characters and affinities, key to genera; principal characters of each genus, diagnoses and synonymy of species in each. Fifteen new species or subspecies described and extended or revised descriptions of a number of others. Affinities of genera, geological distribution. For abstract see 765.

.787 July 17 On the Structure of the Skull in the Elasmobranch Genus *Didymodus*. *Proc. Amer. Philos. Soc.* Vol. XXI, 1884, pp. 572-590, one plate. *Pal. Bull.* No. 38, pp. 572-590, one plate.

Description of partial skull in Cope Collection from Permian of Texas.

.788 July 17 The Condylarthra. *Amer. Nat.* Vol. XVIII, 1884, pp. 790-805; 892-906, Pls. XXVIII-XXX and figs. 1-28.

Affinities, classification, description of principal forms with illustrations. The article appeared in the August number (published July 17) and the September number (published August 15) successively.

.789 July 17 [An International Scientific Association.] *Amer. Nat.* Vol. XVIII, 1884, pp. 805, 806.

Editorial.

.790 July 17 The Duke of Argyll's Unity of Nature. *Amer. Nat.* Vol. XVIII, 1884, pp. 807, 808.

Review of: The Unity of Nature, by the Duke of Argyll. Unsigned. Cited by Frazer.

.791 July 17 The *Choristodera*. *Amer. Nat.* Vol. XVIII, 1884, pp. 815-817.

Critique of: Etude sur les charactéres géneriques du Simædosaure reptile nouveau de la faune Cernaysiene etc. par Dr. Lemoine, 1884. Probably = *Champsosaurus;* position of this group of fossil reptiles.

.792 July 17 The Genus *Pleuracanthus*. *Amer. Nat.* Vol. XVIII, 1884, p. 818, Pl. XXIII.

Figures of specimens from Texas Permian. See 771 for first note.

.793 Aug. 15 Zoological Nomenclature. *Amer. Nat.* Vol. XVIII, 1884, pp. 906-908.

Unsigned editorial. Given under Cope in index of volume.

.794 Aug. 15 Scientific Illustrations. *Amer. Nat.* Vol. XVIII, 1884, p. 908.

Unsigned editorial. Given under Cope in index of volume.

.795 Aug. 24 (The Age of some Formations in the Banks of the Rio Grande). *Proc. Amer. Philos. Soc.* Vol. XXI, 1884, p. 615.

.796 Sept. 15 Observations on the Phylogeny of the Artiodactyla derived from American Fossils. *Amer. Nat.* Vol. XVIII, 1884, pp. 1034-1036.

An advance abstract of 807. It is composed of the paragraphs from the bottom of p. 25 to end of that paper, comprising the author's views of this date in regard to the phylogeny of the families.

.797 Sept. 15 On Catagenesis. *Amer. Nat.* Vol. XVIII, 1884, pp. 970-984. *Proc. A. A. A. S.* XXXIII Meeting 1884, pp. 455-470. Abstract, "Catagenesis; or, Creation by Retrograde Metamorphosis of Energy", *Science* Vol. IV, No. 84, Sept. 12, 1884, pp. 240-243.

Corollary to the doctrines of archæsthetism, etc., discussed in a previous number of the Amer. Nat. The abstract in Science appeared three days previous to the original in the Amer. Nat. The Proc. A. A. A. S. were not published until 1885.

.798 Sept. 15 Scientific Contracts. *Amer. Nat.* Vol. XVIII, 1884, p. 1013.

Unsigned editorial. Under Cope in index of volume.

.799 Oct. 3 Phylogeny of the artiodactyle *Mammalia*. *Science* Vol. IV, No. 87, Oct. 3, 1884, p. 339.

An abstract of 807. See also 796 and note.

.800 Oct. 3 On the Saurians of the Permian Epoch. *Science* Vol. IV, No. 87, Oct. 3, 1884, p. 340.

Abstract of paper in Proc. A. A. A. S.

.801 Oct. 20 The Amblypoda. *Amer. Nat.* Vol. XVIII, 1884, pp. 1110-1121; 1192-1202; Vol. XIX, 1885, pp. 40-55, Pl. I; figs. 1-35.

Ordinal characters, classification, affinities of other ungulate orders; descriptions of principal known types with illustrations. The pages appeared successively in the November number (published Oct. 20), the December number (published Nov. 19) and the January number of 1885 (published Dec. 30, 1884).

.802 Oct. 20 Note on Acceleration in Deer Antlers. *Amer. Nat.* Vol. XVIII, 1884, p. 1160.

See also 785.

.803 Oct. 20 The American Association for the Advancement of Science. *Amer. Nat.* Vol. XVIII, 1884, pp. 1121, 1122.

Unsigned editorial. Under Cope in the index of volume.

.804 Oct. 20 Catalogue of Aquatic Mammals of the United States by F. W. True. *Amer. Nat.* Vol. XVIII, 1884, pp. 1123, 1124.

Review with criticism.

.805 Oct. 20 The Origin of the Mammalia. *Amer. Nat.* Vol. XVIII, 1884, pp. 1136, 1137.

Derived from primitive reptilia, the Permian Pelycosauria approximately represent the ancestral type. Abstract of 819 and 808.

.806 Oct. 21 The Extinct Mammalia of the Valley of Mexico. *Proc. Amer. Philos. Soc.* Vol. XXII, 1884, pp. 1-21. *Pal. Bull.* No. 39, pp. 1-21. Reprinted in Spanish "Los mamiferos dal valle de Mexico ya extinguidos." *Anales, Museo Nacional, Mexico,* T.III, 10*a*, pp. 335-344, 1886.

Based upon study of collections in National and School of Mines Museums of Mexico. Revision of the species of Mastodon, dividing into 3 genera, *Dibelodon,* gen. nov. type *M. shepardi,* Leidy, *Tetrabelodon* gen. nov. type *M. angustidens* Cuv, upon characters of incisors. *Equus,* key to species and descriptions of two new forms; Camelidæ, key to later genera, *Eschatius* gen. nov.

.807 Oct. 21 On the Structure of the Feet in the Extinct Artiodactyla of North America. *Proc. Amer. Philos. Soc.* Vol. XXII, 1884, pp. 21-27. *Pal. Bull.* No. 39, pp. 21-27. *Proc. A. A. A. S.* XXXIII Meeting, 1884, pp. 482-489.

Concise account of principal features of structure of feet in American Tertiary genera; discussion of affinities and evolution; phylogeny of families. For abstract see 796 and 799.

.808 Oct. 21 Fifth Contribution to the Knowledge of the Fauna of the Permian Formation of Texas and the Indian Territory. *Proc. Amer. Philos. Soc.* Vol. XXII, 1884, pp. 28-47, Pl. I. *Pal. Bull.* No. 39, pp. 28-47, Pl. I.

Description of specimens of *Clepsydrops, Cricotus* and *Edaphosaurus;* posterior foot structure in Pelycosauria shows marked affinities to mammalia, especially monotremes; columella auris and quadrate in *Clepsydrops leptocephalus* (postea *Diopeus* Cope = *Theropleura* auct. Case) constructed on pattern distinctly approaching mammalia; articulation of ribs in *Embolophorus* mammaloid; reason for believing that the Mammalia are descendants of the Pelycosauria.

.809 Nov. 19 The Press and Science. *Amer. Nat.* Vol. XVIII, 1884, pp. 1231-1233.

Unsigned editorial. Under Cope in index of volume.

.810 Nov. 19 Original Research in Philadelphia. *Amer. Nat.* Vol. XVIII, 1884, p. 1234.

Unsigned editorial. Under Cope in index of volume.

.811 Nov. 19 The Structure of the *columella auris* in *Clepsydrops leptocephalus.* *Amer. Nat.* Vol. XVIII, 1884, pp. 1253-1255, Pl. XXXVII.

Interpretation of the structure in this Permian reptile bearing upon problem of origin of the mammalian ear ossicles. Abstract of 820. See 808.

.812 Note on the Phylogeny of the Vertebrata. *Amer. Nat.* Vol.
Nov. XVIII, 1884, pp. 1255-1257.
19 Diagram of phyletic relations of the classes of vertebrates. Brief discussion. See also 807.

.813 The psychical Relation of Man to Animals. *Amer. Nat.*
Nov. Vol. XVIII, 1884, pp. 1282-1284.
19 Review of: The psychical Relation of Man to Animals, by Prof. Jos. Le Conte, from the Princeton Review.

.814 (Evolution and the Church.) *Amer. Nat.* Vol. XIX, 1885,
Dec. pp. 55-56.
30 Unsigned editorial. Cited by Frazer.

.815 (Vagaries of Nomenclatures.) *Amer. Nat.* Vol. XIX, 1885,
Dec. pp. 56, 57.
30 Unsigned editorial. Cited by Frazer.

.816 *Rodentia* of the European Tertiaries. *Amer. Nat.* Vol. XIX,
Dec. 1885, p. 67.
30 Review of: Die Nager des europäischen Tertiars nebst Betrachtungen, u. d Organization u. gesch. Entwicklung der Nager überhaupt, von M. Schlosser. Palæontographica, 1884. Unsigned. Cited by Frazer.

.817 Marsh on the Jurassic Dinosauria, Part VIII. *Amer. Nat.*
Dec. Vol. XIX, 1885, pp. 67, 68.
30 Review of: The Principal Characters of the American Jurassic Dinosaurs, Part VIII, Order Theropoda. On the United Metatarsal Bones of *Ceratosaurus*. Amer. Journ. Sci., 1884.

.818 Clevenger on the Evolution of Mind and Body of Man and
Dec. Animals. *Amer. Nat.* Vol. XIX, 1885, pp. 99-101.
30 Review of: Comparative Physiology and Psychology, by S. V. Clevenger.

1885.819 The Relations between the Theromorphous Reptiles and the Monotreme Mammalia. *Proc. A. A. A. S.*, XXXIII Meeting, 1884, pp. 471-482, one plate.
For abstract see 805. See also 808.

.820 The Structure of the *columella auris* in the Pelycosauria. *Mem. Nat. Acad. Sci.* Vol. III, Pt. 1, 1884, pp. 91-95, one plate.
For abstract see 808 and 811.

.821 The Occurrence of Man in the Upper Miocene of Nebraska. *Proc. A. A. A. S.*, XXXIII Meeting, 1884, p. 593.

Abstract only. Tooth and associated specimens figured 1395, Pl. CXIXc.

.822 Batrachia. *Standard Natural History* (Edited by J. S. Kingsley) Vol. III, 1885, pp. 303-344.

.823 Genealogy of the Vertebrates as Learned from Palæontology. *Trans. Vassar Brothers' Institute* Vol. III, pp. 60-80.

See also 824, which is nearly the same paper.

.824 Jan. 19 On the Evolution of the Vertebrata, Progressive and Retrogressive. *Amer. Nat.* Vol. XIX, 1885, pp. 140-148; 234-247; 341-353.

Degeneracy and adaptive specialization; embryological and palaeontological evidence; general relations of the vertebrate classes; broader features in evolution of vertebrate anatomy; the Urochorda; evolution of the Fishes and relationships of the orders; Batrachia, key to the orders, phyletic relations; Reptilia, key to orders, phyletic relations, degenerative features in their evolution; birds; key to orders of mammals, phyletic relations, evolution of feet, vertebræ, dentition, brain; instances of degeneracy; progressive evolution prevalent in higher and more recent groups, retrogressive in earlier and lower forms. The paper appeared successively in the February number (published Jan. 19), the March number (published Feb. 24), and the April number (published March 21).

.825 Jan. 19 [The Report of the Museum of Comparative Zoology.] *Amer. Nat.* Vol. XIX, 1885, pp. 148, 149.

Unsigned editorial. Cited by Frazer.

.826 Jan. 19 [Professor Horace Jayne and the School of Biology.] *Amer. Nat.* Vol. XIX, 1885, pp. 149, 150.

Unsigned editorial. Cited by Frazer.

.827 Jan. 19 [The Origin of Speech.] *Amer. Nat.* Vol. XIX, 1885, pp. 150, 151.

Unsigned editorial. Cited by Frazer.

.828 Jan. 19 The White River Beds of Swift Current River, Northwest Territory. *Amer. Nat.* Vol. XIX, 1885, p. 163.

List of species: *Hemipsalodon grandis* gen. et spec. nov. described. Abstract of 881.

.829 Feb. 24 [The National Museum at Washington.] *Amer. Nat.* Vol. XIX, 1885, pp. 276, 277.

Editorial.

.830 [The Geological Survey of Canada.] *Amer. Nat.* Vol.
Feb. XIX, 1885, pp. 277, 278.
24 Unsigned editorial. Cited by Frazer.

.831 The Position of *Pterichthys* in the System. *Amer. Nat.*
Feb. Vol. XIX, 1885, pp. 289-291, figs. 1, 2.
24 Comparison of *Pterichthys* with modern Tunicates.

.832 Twelfth Contribution to the Herpetology of Tropical Amer-
March ica. *Proc. Amer. Philos. Soc.* Vol. XXII, 1884, pp. 167-
6 194, one plate.
With synopses of the Mexican and Central American species of the genera: *Eumeces, Eutænia, Coluber, Phyllodactylus* and of the genera of the Amphisbaenidae, including the new genus *Aporarchus* from Rio Grande do Sul, Brazil.

.833 The Oldest Tertiary Mammalia. *Amer. Nat.* Vol. XIX,
March 1885, pp. 385-387.
6 Lower Puerco (Polymastodon zone as now known), list of fossil mammals, descriptions of *P. latimolis* n. sp., *Laxolophus adapinus* gen. et sp. nov.; *Chriacus hyattianus* n. sp.; *Sarcothraustes coryphaeus* n. sp.

.834 The Lemuroidea and the Insectivora of the Eocene Period
April of North America. *Amer. Nat.* Vol. XIX, 1885, pp. 457-
20 471, figs. 1-18.
Osteological distinctions between the orders Lemuroidea and Insectivora; relations of the Condylarthra; families and genera Arctocyonidae (including *Achaenodon*).

.835 [The Dimensions of Matter.] *Amer. Nat.* Vol. XIX,
April 1885, p. 482.
20 Criticism of argument for four-dimensional space. Unsigned editorial. Under Cope in index of volume.

.836 [The Bestiarians.] *Amer. Nat.* Vol. XIX, 1885, p. 483.
April Unsigned editorial. Cited by Frazer.
20

.837 The Mammalian Genus *Hemiganus.* *Amer. Nat.* Vol. XIX,
April 1885, pp. 493, 494.
20 *Hemiganus otariidens* sp. nov.

.838 Marsupials from the Lower Eocene of New Mexico. *Amer.*
April *Nat.* Vol. XIX, 1885, pp. 493, 494.
20 *Neoplagiaulax americanus* n. sp., *Ptilodus, Polymastodon attenuatus* n. sp. from Puerco formation.

.839 The Loup Fork Miocene in Mexico. *Amer. Nat.* Vol. XIX,
April 1885, pp. 494, 495.
20 Note on occurrence and fossil mammals.

.840 May 1 Phylogeny of the Placental Mammalia. *Science* Vol. V, No. 117, May 1, 1885, p. 354.

.841 May 1 Pretertiary Vertebrates of Brazil. *Science* Vol. V, No. 117, May 1, 1885, pp. 354, 355.

Abstract of 860.

.842 May 18 [The National Academy of Sciences.] *Amer. Nat.* Vol. XIX, 1885, pp. 583, 584.

Unsigned editorial. Cited by Frazer.

.843 May 18 The Batrachia of the Permian Beds of Bohemia, and the Labyrinthodont from the Bijori Group (India). *Amer. Nat.* Vol. XIX, 1885, pp. 592-594.

Review of: Fauna der Gaskohle in d. Kalksteinen d. Perm. formation Böhmens, von Dr. Anton Fritsch, Bd. II, Heft 1; and "The Labyrinthodont from the Bijori Group" by R. Lydekker, Mem. Geol. Survey India, Ser. IV, Vol. I.

.844 May 18 The Genera of Dinocerata. *Amer. Nat.* Vol. XIX, 1885, p. 594.

Note based upon Marsh's monograph; five genera admitted, two of them new (*Ditetrodon* and *Titheopsis*); the number and characters of lower incisors used to differentiate the genera,

.845 June 20 Original Research, its Motives and Opportunities. *Amer. Nat.* Vol. XIX, 1885, pp. 691-693.

Unsigned editorial. Under Cope in index of volume.

.846 June 20 Marsh on the Dinocerata. *Amer. Nat.* Vol. XIX, 1885, pp. 703-705.

Critical review of: Dinocerata, a Memoir of an Extinct Order of Mammals, by O. C. Marsh. Monograph X, U. S. Geol. Survey, 1885.

.847 July A Six-Horned Giant. *The Museum* Vol. I, No. 3, pp. 33-35.

*Loxolophodon cornutus.*

.848 July 24 A Contribution to the Herpetology of Mexico. *Proc. Amer. Philos. Soc.* Vol. XXII, 1885, pp. 379-404.

The last two pages contain an "Appendix on a Collection from New Providence, Bahama Islands." The collection of the Commission Cientifica. With synopses of the Mexican species of the genera, *Cinosternum, Anolis, Sceloporus;* and a description of a new genus, *Anelytropsis,* of the Anelytropidæ or Typhlophthalmi lizards.

.849 Second Continuation of Researches among the Batrachia of
July the Coal Measures of Ohio. *Proc. Amer. Philos. Soc.* Vol.
24 XXII, 1885, pp. 405-408. *Pal. Bull.* No. 40, pp. 405-408.
*Cercariomorphus* gen. nov.

.850 Scientific Criticism. *Amer. Nat.* Vol. XIX, 1885, pp. 777,
July 778.
28 Unsigned editorial. Under Cope in index of volume.

.851 The Mammalia of the Oligocene of Buenos Ayres. *Amer.*
July *Nat.* Vol. XIX, 1885, pp. 789, 790.
28 Review of: Nuevos restos de mamiferos fosiles Oligocenos
recogidos por el Prof. Pedro Scalabrini y pertenencientes al
Museo provincial de la Ciudad del Parana, por F. Ameghino.
Bul. I Mus. nac. Acad. Sci. di Cordoba, VIII, p. 5.

.852 Applied Metaphysics of Sex. *Amer. Nat.* Vol. XIX, 1885,
July pp. 820-823.
28

.853 Garman on *Didymodus*. *Amer. Nat.* Vol. XIX, 1885, pp.
Aug. 878, 879.
15 Review of: Bull. Museum of Comparative Zoology, XII,
July, 1885.

.854 Origin of Man and Other Vertebrates. *Pop. Sci. Monthly*
Sept. Vol. XXVII, 1885, pp. 605-614, figs. 1-3.

.855 On the Brain and Auditory Organs of a Permian Theromorph
Sept. Saurian. *Science* Vol. VI, No. 136, Sept. 11, 1885, p. 224.
11 Abstract of paper read before the A. A. A. S., 1886. See
883.

.856 [The United States Coast Survey.] *Amer. Nat.* Vol. XIX,
Sept. 1885, p. 974.
22 Unsigned editorial. Cited by Frazer.

.857 The Relations of the Puerco and Laramie Deposits. *Amer.*
Sept. *Nat.* Vol. XIX, 1885, pp. 985, 986.
22 Puerco formation overlies Laramie with characteristic
dinosaurs. Both, however, may be associated in the Post-cretaceous series. *Crocodilus stavilianus* described from
Laramie of New Mexico.

.858 The large Iguanas of the Greater Antilles. *Amer. Nat.*
Sept. Vol. XIX, 1885, pp. 1005, 1006.
22 Notes on distribution; key to species of *Cyclura*.

.859 M. Paul Albrecht's Identifications. *Amer. Nat.* Vol. XIX,
Sept. 1885, pp. 1006-1009.
22 Homologies of skull bones in mammals and lower vertebrates. Critical review. Unsigned. Under Cope in index
of volume.

.860 A Contribution to the Vertebrate Palaeontology of Brazil.
Sept. *Proc. Amer. Philos. Soc.* Vol. XXIII, 1885, pp. 1-21, one
26 plate. *Pal. Bull.* No. 40, pp. 1-21, one plate.

For abstract see 841. Description of skeleton of *Stereosternum* "carboniferous" (Permian) and also *Hyposaurus.* New species of fishes of genera *Apocopodon, Enchodus, Diplomystus, Chiromystus* and *Pycnodus* described.

.861 The Energy of Life Evolution, and how it has acted. *Pop.*
Oct. *Sci. Monthly* Vol. XXVII, 1885, pp. 789-800, figs. 1-9.

.862 The Present Condition of the Yellowstone National Park.
Oct. *Amer. Nat.* Vol. XIX, 1885, pp. 1037-1040.
23

.863 [The Destruction of Animals.] *Amer. Nat.* Vol. XIX,
Oct. 1885, pp. 1077, 1078.
23 Unsigned editorial. Cited by Frazer.

.864 [The Comision cientifica of Mexico.] *Amer. Nat.* Vol.
Oct. XIX, 1885, p. 1079.
23 Unsigned editorial. Cited by Frazer.

.865 Eocene Paddle-fish and Gonorhynchidæ. *Amer. Nat.* Vol.
Oct. XIX, 1885, pp. 1090, 1091.
23 Green River Eocene fish fauna: *Crossopholis* a relative of *Polyodon; Notogoneus osculus* gen. et sp. nov. of Gonorhynchidæ.

.866 Catalogue of the Species of Batrachians and Reptiles con-
Oct. tained in a Collection made at Pebas, Upper Amazon, by
26 John Hauxwell. *Proc. Amer. Philos. Soc.* Vol. XXIII, 1885, pp. 94-103.

With a new genus, *Mionyx,* and a synopsis of the Ecplopodine division of the Teidæ.

.867 Mr. Lydekker on *Esthonyx. Geol. Mag.* n. s. Decade 3,
Nov. Vol. II, 1885, pp. 526, 527.

.868 The Batrachia of the Permian Beds of Bohemia. *Geol.*
Nov. *Mag.* n. s. Decade 3, Vol. II, 1885, p. 527.

.869 [The Political Scientists.] *Amer. Nat.* Vol. XIX, 1885,
Nov. pp. 1186, 1187.
25 Unsigned editorial. Cited by Frazer.

.870 [The Geological Survey of Michigan.] *Amer. Nat.* Vol.
Nov. XIX, 1885, pp. 1187, 1188.
25 Unsigned editorial. Cited by Frazer.

.871 Jordan's Catalogue of Fishes of North America. *Amer. Nat.*
Nov. Vol. XIX, 1885, pp. 1199, 1200.
25 Review of: Catalogue of the Fishes known to inhabit the

Waters of North America north of the Tropic of Cancer, by D. S. Jordan (extracted from Annual Report, U. S. Commissioner of Fish and Fisheries, for 1884).

.872 Polemics in Palæontology. *Amer. Nat.* Vol. XIX, 1885,
Nov. pp. 1207, 1208.
25 Unsigned. Cited by Hay.

.873 The Ankle and Skin of the Dinosaur, *Diclonius mirabilis*.
Nov. *Amer. Nat.* Vol. XIX, 1885, p. 1208, figs. 1-3, of Pl. XXXVII.
25 Note on characters seen in skeleton found by Wortman
and Hill in South Dakota, now mounted in the American
Museum (Cope Collection).

.874 Pliocene Horses of Southwestern Texas. *Amer. Nat.* Vol.
Nov. XIX, 1885, pp. 1208, 1209, figs. 4-6 of Pl. XXXVII.
25 Five species noted; figure of *E. ? crenideus* upper molar,
also of upper molars of *Hippotherium peninsulatum* n. sp.
and *Protohippus castilli* n. sp. from Mexican Tertiary. Abstract of 877.

.875 The Retrograde Metamorphosis of Siren. *Amer. Nat.* Vol.
Nov. XIX, 1885, pp. 1226, 1227.
25

.876 Palæontological Nomenclature. *Geol. Mag.* n. s. Decade 3,
Dec. Vol. II, 1885, pp. 572-575.

.877 Report on the Coal Deposits near Zacualtipan, in the State
Dec. of Hidalgo, Mexico. *Proc. Amer. Philos. Soc.* Vol. XXIII,
2 1885, pp. 146-151, figs. 1, 2.
Geological notes: *Hippotherium peninsulatum* and *Protohippus castilli* further described. For abstract see 874.

.878 [The Indiana Academy of Sciences.] *Amer. Nat.* Vol. XX,
Dec. 1886, pp. 41, 42.
29 Unsigned editorial. Cited by Frazer.

.879 The Batrachian Intercentrum. *Amer. Nat.* Vol. XX, 1886,
Dec. pp. 76, 77.
29 Homologies of the vertebral elements in Permian Batrachia and Reptilia.

.880 The Material Conditions of Memory. *Amer. Nat.* Vol. XX,
Dec. 1886, pp. 83-85.
29

1886.881 The Vertebrata of the Swift Current Creek Region of the Cypress Hills. *Annual Report, Geol. and Nat. Hist. Survey, Canada,* n. s. Vol. I, 1885, Report C, Appendix I, pp. 79c-85c.
See 828 for abstract.

.882 On Two New Forms of Polydont and Gonorhynchid Fishes from the Eocene of the Rocky Mountains. *Mem. Nat. Acad. Sci.* Vol. III, Pt. II, 1885, pp. 159-165, one plate.

Species of *Crassopholis, Notogeneus and Priscacara* (*H. hyssacanthus* N. Sp.) described.

.883 Jan. 21 On the Structure of the Brain and Auditory Apparatus of a Theromorphous Reptile of the Permian Epoch. *Proc. Amer. Philos. Soc.* Vol. XXIII, 1885, pp. 234-238, one plate. *Proc. A. A. A. S.*, XXXIV Meeting, 1885, p. 336-341.

Study of a brain-cast and sectional skull of *Diadectes.* For abstract see 855.

.884 Jan. 23 [The Academy of Original Research.] *Amer. Nat.* Vol. XX, 1886, pp. 140-142.

Editorial. Plan for such an institution.

.885 Jan. 23 The Sternum of the Dinosauria. *Amer. Nat.* Vol. XX, 1886, pp. 153-155, figs. 1, 2.

Description and figures of *Diclonius* and *Monoclonius.* (This element in *Monoclonius* subsequently identified as the "frill" at the back of the neck.)

.886 Jan. 23 Correction of Notes on Dinocerata. *Amer. Nat.* Vol. XX, 1886, p. 155.

*Tetheopsis* founded upon an artefact; basicranium described by Cope in "Tertiary Vertebrata" as *Uintatherium lacustre* is a *Palaeosyops.*

.887 Jan. 23 The Intercentrum in *Sphenodon.* *Amer. Nat.* Vol. XX, 1886, p. 175.

Traces of a true intercentrum are present in this reptile.

.888 Feb. 5 On the Species of Iguaninæ. *Proc. Amer. Philos. Soc.* Vol. XXIII, 1885, pp. 261-271.

.889 Feb. 5 Thirteenth Contribution to the Herpetology of Tropical America. *Proc. Amer. Philos. Soc.* Vol. XXIII, 1885, pp. 271-287.

With a synopsis of the genus *Trimorphodon.*

.890 Feb. 25 (The Bestiarians.) *Amer. Nat.* Vol. XX, 1886, p. 254.

Unsigned editorial. Cited by Frazer.

.891 Feb. 25 An Extinct Dog. *Amer. Nat.* Vol. XX, 1886, p. 271

Notice of J. A. Allen's memoir on *Pachycyon robustus, Mem. Mus. Comp. Zool.* Vol. X, No. 2. Unsigned. Cited by Hay.

.892 Three Problematical Genera of Mexican Boæform Snakes.
Feb. *Amer. Nat.* Vol. XX, 1886, pp. 293, 294.
25 *Charina, Lichanura* and *Loxocemus.* Systematic position.

.893 An Extraordinary Human Dentition. *Amer. Nat.* Vol. XX,
Feb. 1886, p. 297.
25

.894 *Edestus* and *Pelecopterus,* etc. *Geol. Mag.* n. s. Decade 3,
March Vol. III, 1886, p. 141.
*Pelecopterus* not identical with *Ptychodus.*

.895 The Vertebrate Fauna of the *Ticholeptus* Beds. *Amer. Nat.*
March Vol. XX, 1886, pp. 367-369.
23 Mascall and Deep River faunas compared. *Anchitherium ultimum* and *Merycochoerus obliquidens* described from Cottonwood Creek, Oregon (Mascall formation). Abstract of 896.

.896 On Two New Species of Three-toed Horses from the Upper
April Miocene, with Notes on the Fauna of the *Ticholeptus* Beds.
15 *Proc. Amer. Philos. Soc.* Vol. XXIII, 1886, pp. 357-361.
Fuller description and discussion than in abstract; *Hippotherium rectidens* n. sp. from Tehuichila. For abstract see 895.

.897 On the Intercentrum of the Terrestrial Vertebrata. *Trans.*
April *Amer. Philos. Soc.* n. s. Vol. XVI, 1886, pp. 243-253, Pl. I
20 and figs. 1-6. Separates April 20, 1886.

.898 [The Relations of the National Academy of Sciences to the
April Government.] *Amer. Nat.* Vol. XX, 1886, pp. 443, 444.
24 Editorial.

.899 The Plagiaulacidæ of the Puerco Epoch. *Amer. Nat.* Vol.
April XX, 1886, p. 451.
24 *Neoplagiaulax molestus* sp. nov.

.900 Meynert's Psychiatry. *Amer. Nat.* Vol. XX, 1886, pp.
April 474-479.
24 Review of: Psychiatry, a clinical Treatise on Diseases of the Fore-Brain, by Theodor Meynert. Translated by B. Sachs.

.901 Note on *Phenacodus.* *Geol. Mag.* n. s. Decade III, Vol. III,
May 1886, p. 239.

.902 Note on *Erisichthe.* *Geol. Mag.* n. s. Decade III, Vol. III,
May 1886, p. 239.
*Erisichthe* not synonymous with *Protosphyræna.*

.903 [The Missing Link.] *Amer. Nat.* Vol. XX, 1886, pp.
June 534-536.
1 Unsigned editorial. Cited by Frazer.

.904 June 1 [The Congressional Investigation of the United States Geological Survey.] *Amer. Nat.* Vol. XX, 1886, p. 536.
Unsigned editorial.

.905 June 1 The Long-spined *Theromorpha* of the Permian Epoch. *Amer. Nat.* Vol. XX, 1886, pp. 544, 545.
Description of *Naosaurus claviger;* key to species of *Naosaurus.*

.906 July The Phylogeny of the Camelidæ. *Amer. Nat.* Vol. XX, 1886, pp. 611-624, figs. 1-14.
Characteristics of Camelidae; key to genera; description of ancestral series, carried back to "*Pantolestes*" *brachystomus* (i. e., *Diacodexis*).

.907 July [A Government Department of Science and Public Instruction.] *Amer. Nat.* Vol. XX, 1886, pp. 624, 625.
Unsigned editorial. Cited by Frazer.

.908 July Embryology of Armadillos. *Amer. Nat.* Vol. XX, 1886, pp. 667, 668.

.909 Aug. [Theology of Evolution.] *Amer. Nat.* Vol. XX, 1886, pp. 708, 709.
Unsigned editorial. Cited by Frazer.

.910 Aug. [Illustration in United States Geological Survey Work.] *Amer. Nat.* Vol. XX, 1886, pp. 709, 710.
Unsigned editorial. Cited by Frazer.

.911 Aug. Schlosser on the Phylogeny of the Ungulate Mammalia. *Amer. Nat.* Vol. XX, 1886, pp. 719-721.
Critical review of: Beiträge zur Kenntniss der Stammesgeschichte der Hufthiere und Versuch einer Systematik der Paar—und Unpaarhufer, von Max Schlosser. Morph. Jahrbuch. XII, s. 575-580. Taxonomic methods and systematic criteria; origin of the milk dentition.

.912 Aug. The most Southern Salmon. *Amer. Nat.* Vol. XX, 1886, p. 735.
*Salmo purpuratus* from Sierra Madre, Mexico.

.913 Aug. The Habits of *Eublepharis variegatus* Baird. *Amer. Nat.* Vol. XX, 1886, pp. 735, 736.

.914 Aug. The Copperhead and other Snakes. *Amer. Nat.* Vol. XX, 1886, pp. 744, 745.
Fear of hognose and water snake for copperhead.

.915 Aug. 7 On the Structure and Affinities of the Amphiumidæ. *Proc. Amer. Philos. Soc.* Vol. XXIII, 1886. pp. 442-445. Pls. VI, VII.

.916 An Analytical Table of the Genera of Snakes. *Proc. Amer.*
Oct. *Philos. Soc.* Vol. XXIII, 1886, pp. 479-499.
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.917 [The Method of Teaching Natural History.] *Amer. Nat.*
Oct. Vol. XX, 1886, pp. 868, 869.
18 Unsigned editorial. Cited by Frazer.

.918 [The Recent Charleston Earthquake.] *Amer. Nat.* Vol.
Oct. XX, 1886, pp. 869, 870.
18 Unsigned editorial. Cited by Frazer.

.919 [Concerning Appropriations for the United States Geological
Oct. Survey.] *Amer. Nat.* Vol. XX, 1886, p. 870.
18 Editorial.

.920 Systematic Catalogue of the Species of Vertebrata found
Oct. in the Beds of the Permian Epoch in North America with
23 Notes and Descriptions. *Trans. Amer. Philos. Soc.* n. s.
Vol. XVI, 1886, pp. 285-297, Pls. II, III and one figure.
Separates October 23, 1886.

.921 The Origin of the Fittest. D. Appleton & Co., New York,
Nov. 8vo., 1886, pp. i-xix; 1-467; Pls. I-XVIII and figs. 1-81.

.922 Synonymic List of the North American Species of *Bufo* and
Nov. *Rana*, with Descriptions of some New Species of Batrachia,
2 from Specimens in the National Museum. *Proc. Amer.*
*Philos. Soc.* Vol. XXIII, 1886, pp. 514-526.

.923 On Lemurine Reversion in Human Dentition. *Amer. Nat.*
Nov. Vol. XX, 1886, pp. 941-947.
23 The third or second and third upper molars in man are
very commonly tritubercular as in primitive lemuroids instead of quadritubercular as in monkeys and apes. This is
especially true of the higher races of man, and is regarded as
a reversionary character.

.924 [Instruction and Investigation.] *Amer. Nat.* Vol. XX, 1886,
Nov. p. 948.
23 Unsigned editorial. Cited by Frazer.

.925 Schlosser on Creodonta and *Phenacodus*. *Amer. Nat.* Vol.
Nov. XX, 1886, pp. 965-967.
23 Reply to Ueber das Verhältniss der Cope'schen Creodonta
zu den übrigen Fleisch-fressern, von Max Schlosser. *Morph.
Jahrbuch,* XII, 1886, p. 287.

.926 Dollo on Extinct Tortoises. *Amer. Nat.* Vol. XX, 1886,
Dec. pp. 967, 968.
29 Review of: Premiére note sur les Cheloniens de Bruxellien
de la Belgique, par L. Dollo; Bull. Mus. Roy, de Belgique,

1886, p. 75; and Premiére note sur les Cheloniens Landemiens de la Belgique; l. c., p. 129.

.927 An Interesting Connecting Genus of Chordata. *Amer. Nat.*
Dec. Vol. XX, 1886, pp. 1027-1031, fig. 1.
29 *Mycterops ordinatus* gen. et sp. nov. intermediate between Ostracoderms and primitive fishes.

.928 A Giant Armadillo from the Miocene of Kansas. *Amer. Nat.*
Dec. Vol. XX, 1886, pp. 1044-1046.
29 Unsigned. Cited by Hay and Frazer. *Caryoderma snovianum.* Subsequently recognized as limb-armor and tee-bones of a giant tortoise.

1887.929 Catalogue of Batrachians and Reptiles of Central America and Mexico. *Bull. U. S. Nat. Museum,* No. 32, 1887, 98 pp.

.930 The Doctrine of Evolution. *The Agassiz Companion* (Wy-
Jan. andotte, Kansas), Vol. XX, No. 1, Jan., pp. 1-3; No. 2, Feb., p. 14.

.931 [American Biological Instruction.] *Amer. Nat.* Vol. XXI,
Jan. 1887, pp. 59-61.
Unsigned editorial. Cited by Frazer.

.932 The Hyoid Structure in the Amblystomid Salamanders.
Jan. *Amer. Nat.* Vol. XXI, 1887, pp. 87, 88, figs. 1-3.

.933 Vertebrate Palæontology. *Amer. Nat.* Vol. XXI, 1887, pp.
Feb. 164-166.
Statement of circumstances relating to delayed publication of final reports of Hayden Survey on Vertebrate Palaeontology. Unsigned editorial. Under Cope in index of volume.

.934 The Formations of the Belly River of Canada. *Amer. Nat.*
Feb. Vol. XXI, 1887, pp. 171, 172.
Comment on Dawson's report on the geological survey.

.935 The Theology of Evolution. Arnold & Co., Philadelphia,
April 1887, 37 pp. Synopsis, *Amer. Nat.* Vol. XXI, 1887, pp. 1127-1129.
The exact date not known but first criticised on April 28, 1887.

.936 Note (on the genus *Dendrobates*). *Amer. Nat.* Vol. XXI,
April 1887, pp. 310, 311.

.937 [The Odium antitheologicum.] *Amer. Nat.* Vol. XXI, 1887,
April pp. 356, 357.
Unsigned editorial. Cited by Frazer.

.938 The Dinosaurian Genus *Cœlurus.* *Amer. Nat.* Vol. XXI,
April 1887, pp. 367-369.
Remarks upon its affinities (based upon specimens from

Trias of New Mexico, subsequently removed to *Tanystrophaeus* v. Mey. and later made types of *Coelophysis* Cope).

.939 April Sex in Government. *Amer. Nat.* Vol. XXI, 1187, pp. 399, 400.

.940 April 7 Science and Immortality. *Christian Register*, April 7, 1887.

.941 April 28 Synopsis of the Batrachia and Reptilia obtained by H. H. Smith in the Province of Matto Grosso, Brazil. *Proc. Amer. Philos. Soc.* Vol. XXIV, 1887, pp. 44-50. Abstract, "Brazilian Reptilia," *Amer. Nat.* Vol. XXI, 1887, pp. 388, 389.

See also 942.

.942 April 28 Appendix on a *Leptognathus* from San Paolo. *Proc. Amer. Philos. Soc.* Vol. XXIV, 1887, p. 60.

*L. garmani* n. sp.

.943 May The Mesozoic and Cænozoic Realms of the Interior of North America. *Amer. Nat.* Vol. XXI, 1887, pp. 445-462.

Read at the International Geological Congress, 1887. Synopsis of classification, distribution of formations and distinctive features of vertebrate faunae. The Laramie group and Puerco are here included in the Mesozoic as Postcretacic system.

.944 May Kedzie's Gravitation, Solar Heat, and Sun Spots. *Amer. Nat.* Vol. XXI, 1887, pp. 464, 465.

Review of: Solar Heat, Gravitation, and Sun Spots, by Prof. J. H. Kedzie.

.945 May American Triassic Rhynchocephalia. *Amer. Nat.* Vol. XXI, 1887, p. 468.

*Typothorax* from Triassic of New Mexico.

.946 May Some New Tæniodonta of the Puerco. *Amer. Nat.* Vol. XXI, 1887, p. 469.

Additional specimens of *Psittacotherium* described.

.947 May Mr. Hill on the Cretaceous of Texas. *Amer. Nat.* Vol. XXI, 1887, pp. 469, 470.

Review of: The Cross-timbers of Texas, by R. T. Hill. Read before the Washington Philos. Soc.

.948 June [The Michigan Geological Survey.] *Amer. Nat.* Vol. XXI, 1887, p. 551.

Unsigned editorial.

.949 June The Sea-Saurians of the Fox Hills Group. *Amer. Nat.* Vol. XXI, 1887, pp. 563-565.

Describes *Piptomerus* gen. nov. with three species, and a new species of Orophosaurus from fragmentary material obtained in New Mexico.

.950 June The Marsupial Genus *Chirox*. *Amer. Nat.* Vol. XXI, 1887, pp. 566, 567, figs. 1, 2.

Description of palate with upper dentition.

.951 June Evolution and Idealism. *Amer. Nat.* Vol. XXI, 1887, pp. 594, 595.

.952 July [The International Congress of Geologists.] *Amer. Nat.* Vol. XXI, 1887, pp. 643-645.

Unsigned editorial. Cited by Frazer.

.953 July Pavlow on the Ancestry of Ungulates. *Amer. Nat.* Vol. XXI, 1887, pp. 656-658.

Critical review of: Études sur l'histoire paléontologique des Ongulés en Amérique et en Europe. I—Groupe primitive de l'Eocène inférieur.

.954 July [Note on the Brain-case of *Belodon buceros.*] *Amer. Nat.* Vol. XXI, 1887, pp. 659, 660.

Verbal communication to the Amer. Philos. Soc.

.955 July 2 On a New Species of *Tropidonotus* found in Washington. *Proc. U. S. National Museum* Vol. X, 1887, p. 146,

*T. bisectus.*

.956 July 7 Montgomery on the Theology of Evolution. *Open Court* Vol. I, No. 11, July 7, 1887, pp. 285-288; Vol. I, No. 13, Aug. 4, 1887 pp. 358-361.

Reprinted as a pamphlet under the title, "A Review of the Theology of Evolution; A Reply to Dr. Montgomery."

.957 July 8 A Contribution to the History of the Vertebrata of the Trias of North America. *Proc. Amer. Philos. Soc.* Vol. XXIV, 1887, pp. 209-228, Pls. I, II.

Based chiefly upon New Mexican collections. Additional notes on *Eupelor, Typothorax, Belodon, Tanystrophaeus* (olim *Coelurus,* postea *Coelophysis*); *Episcoposaurus* gen. nov.

.958 Sept. The American Association at New York. *Amer. Nat.* Vol. XXI, 1887, pp. 833-835.

Unsigned editorial. Under Cope in index of volume.

.959 Sept. The American Committee of the International Congress of Geologists. *Amer. Nat.* Vol. XXI, 1887, pp. 835, 836.

Unsigned editorial. Under Cope in index of volume.

.960 Sept. The Death of Spencer F. Baird. *Amer. Nat.* Vol. XXI, 1887, pp. 836, 837.

Unsigned editorial. Under Cope in index of volume.

.961 Sept. What is the Object of Life? *The Forum* Vol. IV, pp. 49-57.

.962 Sept. 15 Descriptions of New Species of Mexican Reptiles. *Proc. U. S. Nat. Museum* Vol. IX, pp. 184, 188, 189, 190, 196.

These pages are in an article, "Catalogue of Animals collected by the Geographical and Exploring Commission of the Republic of Mexico," by M. Fernando Ferrari-Perez.

.963 Oct. Scott and Osborn on White River Mammalia. *Amer. Nat.* Vol. XXI, 1887, pp. 924-926.

Review of: Preliminary Account of the Fossil Mammals from the White River Formation contained in the Museum of Comparative Zoology, Cambridge, Mass., by W. B. Scott and H. F. Osborn. *Bull. Mus. Comp. Zoo.* Vol. XIII, No. 5.

.964 Oct. Marsh on New Fossil Mammalia. *Amer. Nat.* Vol. XXI, 1887, pp. 926, 927.

Review of: Notice of New Fossil Mammals by O. C. Marsh. *Amer. Journ. Sci.,* Oct., 1887, p. 323.

.965 Oct. Scott on Creodonta. *Amer. Nat.* Vol. XXI, 1887, p. 927.

Review of: On some New and Little-known Creodonta, by W. B. Scott, *Journ. Acad. Nat. Sci. Phila.,* Aug. 10, 1887.

.966 Oct. Scientific Theism. *Amer. Nat.* Vol. XXI, 1887, pp. 948-951.

Review of: Scientific Theism, by Francis Ellingwood Abbot, 2d edition.

.967 Oct. 23 The Relation of Mind to Matter. *Open Court* Vol. I, No. 19, Oct. 27, 1887, pp. 527-530.

.968 Nov. The Perissodactyla. *Amer. Nat.* Vol. XXI, 1887, pp. 985-1007; 1060-1076; Pls. XXVIII-XXXIV; figs. 1-44.

The paper appeared successively in the November and December numbers. Structure and origin of the Perissodactyl foot; characters and evolution of the cheek teeth; synopsis of families and review of principal genera in each, with illustrations of important specimens, generic keys, and phylogenies.

.969 Nov. The Relation of Mind to Matter. *Amer. Nat.* Vol. XXI, 1887, pp. 1007, 1008.

Unsigned editorial. Under Cope in index of volume.

.970 Nov. Synopsis of the Flora of the Laramie Group. *Amer. Nat.* Vol. XXI, 1887, pp. 1011, 1012.

Review of: Synopsis of the Flora of the Laramie Group, by Lester F. Ward, Ann. Report, U. S. Geol. Survey of the Territories, 1886, p. 400.

.971 Nov. Zittel's Manual of Palæontology. *Amer. Nat.* Vol. XXI, 1887, pp. 1014-1019.

Review of: Handbuch der Palæontologie, von K. A. von Zittel, Abtheilungen I, Palaezoölogie, Lief. I, Pisces, etc., 1887. Chiefly a synopsis of Cope's own views on the classification of the fishes, etc.

.972 Nov. A Saber-tooth Tiger from the Loup Fork Beds. *Amer. Nat.* Vol. XXI, 1887, pp. 1019, 1020.

*Machaerodus catocopis* from Republican River beds in Kansas.

.973 Nov. 3 List of the Batrachia and Reptilia of the Bahama Islands. *Proc. U. S. Nat. Museum* Vol. X, 1887, pp. 436-439.

.974 Nov. 29 The Classification and Phylogeny of the Artiodactyla. *Proc. Amer. Philos. Soc.* Vol. XXIV, 1887, pp. 377-400.

Key to families; phylogeny of families; synopsis of principal genera in each family with key and phylogeny. See also 1031.

.975 Dec. Thomas on Mammalian Dentition. *Amer. Nat.* Vol. XXI, 1887, pp. 1134, 1135.

Review of: On the Homologies and Succession of the Teeth in the Dasyuridæ, with an attempt to trace the History of the Evolution of Mammalian Teeth in General, by Oldfield Thomas, Philos. Trans. Roy. Soc., 1887, p. 443.

.976 Dec. The Carboniferous Genus *Stereosternum*. *Amer. Nat.* Vol. XXI, 1887, p. 1109.

Notes on a nearly entire skeleton from Sao Paolo, Brazil.

.977 Dec. The Pug-dog and the Chihuahua Dog. *Amer. Nat.* Vol. XXI, 1887, pp. 1125, 1126.

Generically distinct from *Canis* on basis of number of teeth; genera *Synagodus* and *Dysodus*.

Unsigned. Cited by Frazer.

.978 Dec. The Death of Ferdinand V. Hayden. *Amer. Nat.* Vol. XXI, 1887, pp. 1134, 1135.

Unsigned. Cited by Frazer.

.979 Dec. Lydekker, Boulenger and Dollo on Fossil Tortoises. *Geol. Mag.* n. s. Decade 3, Vol. IV, 1887, pp. 572, 573.

1888.980 Jan. 5 Evolution and Idealism. *Open Court* Vol. I, No. 23, Jan. 5, 1888, pp. 655-657. Reprint, *Amer. Nat.* Vol. XXII, 1888, pp. 81-84.

.981 Jan. 10 The Mechanical Origin of the Sectorial Teeth of the Carnivora. *Proc. A. A. A. S.* XXXVI Meeting, 1887, pp. 254-257. Separates dated Jan. 10, 1888.

The Rodentia are derived from the Tillodontia, certain Taeniodonta being largely intermediate in structure of teeth. The Taeniodonta may also (footnote) be structurally ancestral to the Edentata. Evolution of the characteristic palinal jaw movement in rodents causing the evolution of their characteristic dentition (through kinetogenesis).

.982 Feb. 3 The Mechanical Origin of the Dentition of the Rodentia. *Amer. Nat.* Vol. XXII, 1888, pp. 3-11, figs. 1-9.

Derivation of the order from Tillodont-Taeniodont group. Character of jaw movements in rodents and mechanical effect upon the tooth structures. Parallelism in Multituberculata.

.983 Feb. 3 Note on the Marsupialia Multituberculata. *Amer. Nat.* Vol. XXII, 1888, pp. 12, 13.

Structure of their teeth indicates palinal movement of jaws as in Rodentia.

.984 Feb. 3 (On Local Names.) *Amer. Nat.* Vol. XXII, 1888, pp. 44, 45.

Unsigned editorial. Cited by Frazer.

.985 March 1 Note (on Dr. Montgomery's argument.) *Open Court* Vol. II, No. 27, March 1, 1888, p. 777.

.986 April 2 The Vertebrate Fauna of the Puerco Epoch. *Amer. Nat.* Vol. XXII, 1888, pp. 161-163.

Abstract of 1009. The Puerco a distinct epoch: characters of the mammalian fauna. All plantigrade pentadactyl bunodonts and nearly all have tritubercular molars. Multituberculata present. Perissodactyls and Rodents absent. Fauna ancestral to Eocene and later faunae.

.987 April 2 Schlosser on the Caenozoic Marsupials and Unguiculata. *Amer. Nat.* Vol. XXII, 1888, pp. 163, 164.

Critical review of: Die Affen, Lemuren, Cheiropteren, Insectivoren, Marsupialier, Creodonten u. Carnivoren d. europäischen Tertiärs, von Max Schlosser. Teil I, 1887.

.988 April 2 Lydekker's Catalogue of Fossil Mammalia in the British Museum, Part V. *Amer. Nat.* Vol. XXII, 1888, pp. 164, 165.

Critical review of: Catalogue of the Fossil Mammalia in the British Museum, Part V—containing the Tillodontia, Sirenia, Cetacea, Edentata, Marsupialia, Monotremata and Supplement, by Richard Lydekker, 1887.

.989 April 3 On the Dicotylinæ of the John Day Miocene of North America. *Proc. Amer. Philos. Soc.* Vol. XXV, 1888, pp. 62-79.

.990 April 4 On the Mechanical Origin of the Dentition in the Amblypoda. *Proc. Amer. Philos. Soc.* Vol. XXV, 1888, pp. 80-88, figs. 1-6.

.991 April 21 Seebohm on the *Charuariidæ*. *Amer. Nat.* Vol. XXII, 1888, pp. 236, 237.

Review of: The Geographical Distribution of the *Charadriidæ,* by Henry Seebohm, 1887.

.992 April 21 The Multituberculata Monotremes. *Amer. Nat.* Vol. XXII, 1888, p. 259.

Vestigial teeth of *Ornithorhynchus* indicate that the Multituberculates belong to this group instead of the Marsupials.

.993 April 21 The Cope-Montgomery Discussion. *Amer. Nat.* Vol. XXII, 1888, pp. 264-267.

Discussion of "The Theism of Evolution." Synopsis of Cope's views presented in "The Open Court" during 1887.

.994 April 27 Vertebrate Fauna of the Puerco Series. *Science* Vol. XI, No. 273, April 27, 1888, p. 198.

Abstract of 1009.

.995 May 25 Glyptodon from Texas. *Amer. Nat.* Vol. XXII, 1888, pp. 345, 346.

*G. petaliferus* sp. nov. based on a single plate of the carapace, from Nueces Co., Texas.

.996 May 31 What Mind is. *Open Court,* Vol. II, No. 40, May 31, 1888, pp. 991-993.

.997 June 14 The Physical Basis of Mind. *Open Court,* Vol. II, No. 42, June 14, 1888, p. 1034.

.998 June 29 (Privileged Persons in Science.) *Amer. Nat.* Vol. XXII, 1888, pp. 433-435

Unsigned editorial. Cited by Frazer. Illustrations versus descriptions.

.999 June 29 [The Purchase of Intelligence.] *Amer. Nat.* Vol. XXII, 1888, p. 435.

Credit for work of assistants.

.1000 June 29 Baur's Morphogeny of the Carpus and Tarsus of the Vertebrata. *Amer. Nat.* Vol. XXII, 1888, pp. 435-437.

Review of: Beiträge zur Morphogenie des Carpus and Tarsus der Vertebraten, von Dr. G. Baur, Theil I—Batrachia.

.1001 The Phylogeny of the Horses. *Amer. Nat.* Vol. XXII, 1888,
June pp. 448, 449.
29 Critical review of: Études sur l'histoire palæontologique des Ongulés, II—Le Développement des Equidæ, par Marie Pavlow, 1888. Exception taken to Pavlow's exclusion of genus *Hipparion* from ancestry of Equidæ on basis of divergent characters of certain European species.

.1002 The *ossicula auditus* of the Batrachia. *Amer. Nat.* Vol. XXII,
June 1888, pp. 464-467, Pl. VI.
29 Abstract of paper read before the National Academy of Sciences, April 18, 1888. For complete form of paper see 1022.

.1003 On the Tritubercular Molar in Human Dentition. *Journ.*
July *Morph.* Vol II, 1888, pp. 7-26, Pls. II, III and fig.

.1004 On a New Species of *Bufo* from Texas. *Proc. U. S. Nat.*
July *Museum,* Vol XI, 1888, pp. 317, 318.
5 *Bufo aduncus.*

.1005 On the Snakes of Florida. *Proc. U. S. Nat. Museum* Vol.
July XI, 1888, pp. 381-394, Pl. XXXVI, figs. 3, 4.
5 With a key to the genus *Ophibolus.*

.1006 Catalogue of the Batrachia and Reptilia brought by William
July Taylor from San Diego, Texas. *Proc. U. S. Nat. Museum*
5 Vol XI, 1888, pp. 395-398, Pl. XXXVI, fig. 2.
Including a new genus of lizard, *Lysoptychus.*

.1007 On the Eutæniæ of Southeastern Indiana. *Proc. U. S. Nat.*
July *Museum* Vol. XI, 1888, pp. 399-401.
5

.1008 On the Shoulder-girdle and Extremities of *Eryops. Trans.*
July *Amer. Philos. Soc.* n. s. Vol. XVI, 1888, pp. 362-367, one
20 plate. Separates July 20, 1888.
Figures 4 and 4a erroneously numbered 1 and 2 on Plate.

.1009 Synopsis of the Vertebrate Fauna of the Puerco Series.
Aug. *Trans. Amer. Philos. Soc.* n. s. Vol. XVI, 1888, pp. 298-
1 361, Pls. IV, V and figs. 1-12. Separates August 1, 1888.
For abstract see 986 and 994.

.1010 [A National Zoölogical Park at Washington.] *Amer. Nat.*
Aug. Vol. XXII, 1888, pp. 515, 516.
8 Unsigned editorial. Cited by Frazer.

.1011 The Relation of Will to the Conservation of Energy. *Amer.*
Aug. *Nat.* Vol. XXII, 1888, pp. 551-555.
8 Abstract of paper read before the Philosophical Society of Washington under the title, "The Relation of Consciousness to Animal Motion," on May 26, 1888.

.1012 Aug. 30 (Notes on *Cœlosteus ferox* Newberry and *Titanichthys clarkii* Newberry.) *Amer. Nat.* Vol. XXII, 1888, pp. 637, 638.

Unsigned. Cited by Hay. Brief description of remains.

.1013 Aug. 30 Topinard on the Latest Steps in the Genealogy of Man. *Amer. Nat.* Vol. XXII, 1888, pp. 660-663.

Review of: Les dernières de la génealogie de l'homme. Leçon de Mars 1888, Revue d' Anthropol. May 1888. Gives a subordinal classification of Taxaeopoda (including Hyracoids, Condylarths and Primates) and a phyletic arrangement of the families.

.1014 Sept. 30 Goode's American Fishes. *Amer. Nat.* Vol. XXII, 1888, pp. 714-716, Pl. XIII.

Review of: American Fishes. A Popular Treatise upon the Game and Food Fishes of North America, by G. Brown Goode, 1888.

.1015 Sept. 30 Osborn on the Mesozoic Mammalia. *Amer. Nat.* Vol. XXII, 1888, pp. 723, 724; Pl. XIV.

Review of: The Structure and Classification of the Mesozoic Mammalia, by Prof. H. F. Osborn, *Journ. Acad. Nat. Sci. Phila.*, 1888, pp. 186-265.

.1016 Sept. 30 Lydekker on the Ichthyosauria and Plesiosauria. *Amer. Nat.* Vol. XXII, 1888, pp. 724-726.

.1017 Oct. Mesozoic Realm. *Amer. Geol.* Vol. II, 1888, pp. 261-268.

Abstract, reports, American committee, International Congress of Geologists.

.1018 Oct. Cenozoic Realm. *Amer. Geol.* Vol. II, 1888, pp. 285-299.

Abstract, reports, American committee, International Congress of Geologists.

.1019 Oct. The Relation of the Sexes to Government. *Pop. Sci. Monthly* Vol. XXXIII, 1888, pp. 721-730.

.1020 Oct. 24 (Irrigation of the Arid Region of the United States.) *Amer. Nat.* Vol. XXII, 1888, pp. 821, 822.

Unsigned editorial. Cited by Frazer. Discussion of Powell's proposal for government reservoirs in Rocky Mountain region.

.1021 Oct. 24 Rütimeyer on the Classification of Mammalia, and on American Types recently found in Switzerland. *Amer. Nat.* Vol. XXII, 1888, pp. 831-835.

Review of: Ueber einige Beziehungen zwischen den Saügethierstammen alter u. neuer Welt. Erster Nachtrag zu der Eocenen Fauna der Egerkingen, von L. Rütimeyer, Abhandl, Schweiz. Palæontol. Gesell. Bd. XV, 1888. Reply to criticisms of Cope's classification of Ungulata by their foot-structure; acknowledges Rütimeyer's priority in elucidating structure of molar teeth.

.1022 Nov. On the Relation of the Hyoid and Otic Elements of the Skeleton in the Batrachia. *Journ. Morph.* Vol. II, 1888, pp. 297-310, Pls. XXII-XXIV.

For abstract see 1002.

.1023 Nov. 8 On a New Species of *Charina* from California. *Proc. U. S. Nat. Museum* Vol. XI, 1888, p. 88, Pl. XXXVI, fig. 1.

*Charina brachyops* from Point Reyes.

.1024 Nov. 15 The Marriage Problem. *Open Court* Vol. II, pp. 1307-1310; 1320-1324.

The article appeared successively November 15 and 22.

.1025 Nov. 22 The Pineal Eye in Extinct Vertebrates. *Amer. Nat.* Vol. XXII, 1888, pp. 914-917, Pls. XV-XVIII. Abstract, Proc. *A. A. A. S.* XXXVI Meeting, 1887, p. 254.

Presence in Ostracoderms, *Cricotus, Diadectes;* characters of brain cast in *Diadectes* and *Belodon.*

.1026 Nov. 22 (Defeat of the Appropriation for a Zoölogical Park at Washington.) *Amer. Nat.* Vol. XXII, 1888, pp. 918, 919.

Unsigned editorial. Cited by Frazer.

.1027 Dec. 3 Sketches of the Cascade Mountains of Oregon. *Amer. Nat.* Vol. XXII, 1888, pp. 996-1003, Pl. XIX and Pl. XXI, published in Vol. XXIII.

.1028 Dec. 3 (The National Attitude toward Scientific Research.) *Amer. Nat.* Vol. XXII, 1888, pp. 1003-1005.

Unsigned editorial. Cited by Frazer.

.1029 Dec. 3 Handbuch der Palæontologie of Zittel. *Amer. Nat.* Vol. XXII, 1888, pp. 1018, 1019.

Handbuch der Palæontologie, Band III, Teleostei (finis) et Batrachia, 1888.

.1030 Dec. 3 Schlosser on Carnivora. *Amer. Nat.* Vol. XXII, 1888, pp. 1019, 1020.

Review of: Die Affen, Lemur, Chieropteren, Insectivoren, Marsupialia, Creodonten u. Carnivoren des Europaischen Tertiärs, von Max Schlosser, Abtheil. II, 1888.

.1031 Dec. 26 The Artiodactyla. *Amer. Nat.* Vol. XXII, 1888, pp. 1079-1095, Pls. XXV-XXVIII and figs. 1-6; Vol. XXIII, 1889, pp. 111-136, Pls. III-VII and figs. 7-21.

A modified form of 974. Diagnosis of order, key to families and their phylogenetic relations; synopsis of genera in each family with illustrations of principal types.

.1032 Dec. 26 *Goniopholis* in the Jurassic of Colorado. *Amer. Nat.* Vol. XXII, 1888, pp. 1106, 1107.
*Amphicotylus* Cope = *Goniopholis* Owen; skull of *G. lucasii* described.

.1033 Dec. 26 A Horned Dinosaurian Reptile. *Amer. Nat.* Vol. XXII, 1888, pp. 1108, 1109.
Note upon Prof. Marsh's articles on Ceratops in *Amer. Journ. Sci.* Dec., 1888. Probably identical with an unnamed disosaur described by Cope in 1877.

.1034 Dec. 26 Broca's Convolution in the Apes. *Amer. Nat.* Vol. XXII, 1888, p. 1124.
Criticism on Hervé's article in Bull. Soc. d'Anthropol. de France, April, 1888.

.1035 Dec. 27 Reply to Mrs. M. M. E. on Marriage Time-Contracts. *Open Court* Vol. II, No. 70, Dec. 27, 1888, pp. 1387-1388.

1889.1036 The Batrachia of North America. *Bull. U. S. Nat. Museum,* No. 34, 1889, 525 pp., LXXXVI Pls. and 119 figs.
This work still occupies the field as the only comprehensive treatise on North American amphibians.

.1037 Jan. The Mechanical Origin of the Hard Parts of the Mammalia. *Amer. Nat.* Vol. XXIII, 1889, pp. 71-73.
Abstract of 1062.

.1038 Jan. 14 Evolution of Man. *Brooklyn Times,* Jan. 14, 1889, p. 3.
Lecture before Brooklyn Unitarian Church.

.1039 Feb. Woman Suffrage. *Pop. Sci. Monthly* Vol. XXXIV, 1889, pp. 558, 559.

.1040 Feb. 14 Mrs. M. M. E. on Marriage Contracts. *Open Court* Vol. II, No. 77, p. iii of cover; Feb. 14, 1889.

.1041 March 1 (The American Society of Naturalists.) *Amer. Nat.* Vol. XXIII, 1889, pp. 32, 33.
Unsigned editorial. Cited by Frazer.

.1042 March 1 Catalogue of the Fossil Reptilia and Batrachia of the British Museum. Pt. I, by Dr. Lydekker. *Amer. Nat.* Vol. XXIII, 1889, p. 43.
Review.

.1043 March 14 What was Matriarchy? *Open Court,* Vol. III, No. 81, pp. 1518, 1519.

.1044 March 21 Ethical Evolution. *Open Court,* Vol. III, No. 82, pp. 1523-1529.

.1045 April 12 The Age of the Denver Formation. *Science,* Vol. XIII, No. 323, April 12, 1889, p. 290.

.1046 May 15 The Descent of Man. *Modern Science Essayist,* Vol. I, No. 7, 1889, pp. 161-170, and 175.

.1047 May 30 The Need of an Academic Chair for the Teaching of Evolution. *Open Court,* Vol. III, No. 92, p. 1650.

.1048 May 31 On the Mammalia obtained by the Naturalist Exploring Expedition to Southern Brazil. *Amer. Nat.* Vol. XXIII, 1889, pp. 128-150.

.1049 May 31 The Vertebrate Fauna of the Equus Beds. *Amer. Nat.* Vol. XXIII, 1889, pp. 160-165.

Lists of species from Silver Lake, Oregon, from southwest Texas, valley of Mexico, and from (Washtuckua Lake) Whitman Co., Washington; *Alces brevitrabalis* and *semipalmatus, Cariacus ensifer* described from the last locality.

.1050 June 1 A Review of the North American Species of *Hippotherium. Proc. Amer. Philos. Soc.* Vol. XXVI, 1889, pp. 429-458, three plates.

.1051 June 28 (The Post-Darwinians.) *Amer. Nat.* Vol. XXIII, 1889, pp. 136, 137.

Editorial.

.1052 June 28 Credner on *Palæohatteria. Amer. Nat.* Vol. XXIII, 1889, pp. 148, 149 (bis).

Critical review of Credner's paper.

1053. June 28 Brongniart and Döderlein on Xenacanthina. *Amer. Nat.* Vol. XXIII, 1889, pp. 149, 150.

Review of: Études sur le terrain Houillier de Commentry, par C. Brongniart et E. Sauvage, and Döderlein's article in the "Zoologischer Anzeiger," March, 1889.

.1054 June 28 The Vertebrata of the Swift Current River, II. *Amer. Nat.* Vol. XXIII,. 1889, pp. 151-155.

Preliminary notice of additional collections obtained in

1888. "*Chalicotherium*" *hilobatum* n. sp., *Haplacodon* gen. et. sp. nov. five new species of White River mammalia.

.1055 Mr. Lydekker on *Phenacodus* and the Athecæ. *Nature,*
July Vol. XL, July 25, 1889, p. 298.
25

.1056 The Proboscidia. *Amer. Nat.* Vol. XXIII, 1889, pp. 191-211,
Aug. Pls. IX-XVI, figs. 1-9. Abstract, "Prof. Cope on the *Pro-*
15 *boscidea,*" *Geol. Mag.* Decade 3, Vol. VI, pp. 438-448, Pl. XIII, figs. 1-8.

Synopsis of characters and affinities, key to families and genera, list of species and key to those of North America; phylogeny; illustrations of several Tertiary American Mastodons and comparative diagrams of skulls of American and Old World Proboscideans.

.1057 [Original Research in Pennsylvania.] *Amer. Nat.* Vol.
Aug. XXIII, 1889, pp. 243, 244.
15 Unsigned editorial. Cited by Frazer.

.1058 [The U. S. National Academy.] *Amer. Nat.* Vol. XXIII,
Aug. 1889, pp. 244, 245.
15 Unsigned editorial. Cited by Frazer.

.1059 [The American Society of Psychical Research.] *Amer.*
Aug. *Nat.* Vol. XXIII, 1889, p. 245.
15 Unsigned editorial. Cited by Frazer.

.1060 An Intermediate Pliocene Fauna. *Amer. Nat.* Vol. XXIII,
Aug. 1889, pp. 253, 254.
15 Collection sent in by Duncan from "Oregon Desert." *Hippotherium relictum* n. sp. described. (The collection appears to be an admixture of specimens from two or more formations. W. D. M.)

.1061 Storms on the Adhesive Disk of *Echeneis.* *Amer. Nat.*
Aug. Vol. XXIII, 1889, pp. 254, 255.
15 Review of: Paper by Storms in Ann. & Mag. Nat. Hist. Ser. 6, Vol. II, p. 67.

.1062 The Mechanical Causes of the Development of the Hard
Sept. Parts of the Mammalia. *Journ. Morph.* Vol. III, 1889, pp. 137-290, Pls. IX-XVI, figs. 1-93.

For abstract see 1037.

.1063 Note on *Hippotherium rectidens.* *Proc. Amer. Philos. Soc.*
Sept. Vol. XXVI, 1889, p. 458.
11

.1064 An Outline of the Philosophy of Evolution. *Proc. Amer.*
Nov. *Philos. Soc.* Vol. XXVI, 1889, pp. 495-505.
18

.1065 Nov. 18 On a Species of *Plioplarchus* from Oregon. *Amer. Nat.* Vol. XXIII, 1889, pp. 625, 626.

*P. septemsipinosus* n. sp. from shales near Van Horn's ranch, John Day R., Oregon. Discussion of geologic age of these shales. (Now referred to the Mascall; see Merriam 1901, Bull. Dept. Geol. Univ. Cal. Vol. II, p. 308).

.1066 Nov. 18 On a New Genus of Triassic Dinosauria. *Amer. Nat.* Vol. XXIII, 1889, p. 626.

*Cœlophysis* gen. nov. based upon three species from the Triassic of New Mexico previously referred to *Coelurus* Marsh and to *Tanystrophaeus* von Meyer.

.1067 Nov. 18 Vertebrata of Swift Current River, No. III. *Amer. Nat.* Vol. XXIII, 1889, pp. 628, 629.

Additional note describing three new species. See 1054.

.1068 Nov. 28 Lamarck versus Weisman. *Nature* Vol. XLI, November 28, 1889, p. 79.

.1069 Dec. 1 [A National Flower.] *Amer. Nat.* Vol. XXIII, 1889, pp. 484, 485.

Unsigned editorial. Cited by Frazer. Suggests the Mountain Laurel, or still better the Tulip-tree.

.1070 Dec. 1 [Science in Newspapers.] *Amer. Nat.* Vol. XXIII, 1889, p. 485.

Unsigned editorial. Cited by Frazer.

.1071 Dec. 1 Marsh on Cretaceous Mammalia. *Amer. Nat.* Vol. XXIII, 1889, pp. 490, 491.

Critical review of: Discovery of Cretaceous Mammalia, by O. C. Marsh, Amer. Journ. Sci. 1889, p. 81.

1890.1072 Syllabus of a Course of Lectures on Geology and Paleontology. Part I—Geology. Ferris Bros., Philadelphia, 8vo., 1890, 49 pp., 9 figs.

.1073 Jan. 3 Two Perils of the Indo-European. *Open Court* Vol. III, pp. 2052-2054; 2070, 2071.

This article appeared successively January 3 and January 30, 1890.

.1074 Jan. 5 The Edentata of North America. *Amer. Nat.* Vol. XXIII, 1889, pp. 657-664, Pls. XXXI, XXXII, figs. 1, 2.

Synopsis of suborders and families; key to genera of Megatheriidæ, and Glyptodontidæ; phylogeny. Figures of *Caryoderma* etc. [*Caryoderma* is now known to be a tortoise.]

.1075 Jan. 5 Pohlig on *Elephas antiquus*. *Amer. Nat.* Vol. XXIII, 1889, pp. 712, 713.

Review of Monographie der *Elaphas antiquus,* Falc., führenden Travertine Thüringens, ihrer Fauna und Flora. Theil I, *Nova Acta* Vol. LIII, 1888, s. 259.

.1076 The Horned Dinosauria of the Laramie. *Amer. Nat.* Vol.
Jan. XXIII, 1889, pp. 715-717, Pls. XXXIII, XXXIV.
5 Additional notes on *Monoclonius*, with figures or horn cores
in three species, two of them new. Family Agathaumantidæ.

.1077 (Charges against the methods of the Paleontological Depart-
Jan. ment of the U. S. Geological Survey.) *New York Herald*,
12 Jan. 12 and 20, 1890.

.1078 [Opinions as to the Essential Nature of Organic Evolution.]
Feb. *Amer. Nat.* Vol. XXIV, 1890, pp. 49-51.
3 Unsigned editorial. Cited by Frazer.

.1079 Scientific Results of Explorations by the U. S. Fish Com-
Feb. mission steamer "Albatross," No. III—Report on the
5 Batrachians and Reptiles collected in 1887-1888. *Proc. U. S.
Nat. Museum* Vol. XII, 1889, pp. 141-147. Separates Feb. 5,
1890.

.1080 (Exposition of Abuses among Geologists and Palæontol-
Feb. ogists.) *Amer. Nat.* Vol. XXIV, 1890, pp. 158, 159.
28 Unsigned editorial. Cited by Frazer.

.1081 A. Smith Woodward on *Cœlorhynchus* Agassiz. *Amer. Nat.*
Feb. Vol. XXIV, 1890, pp. 165, 166.
28 Review of Woodward's paper in Ann. & Mag. Nat. Hist.
Sept. 1888. Unsigned. Cited by Hay.

.1082 Synopsis of the Families of Vertebrata. *Amer. Nat.* Vol.
March XXIII, 1889, pp. 849-877.
13 Family classification.

.1083 Notes on the Dinosauria of the Laramie. *Amer. Nat.* Vol.
March XXIII, 1889, pp. 904-906.
13 *Pteropelyx grallipes* gen. et sp. nov. (Trachodont, Judith
River); notes on Agathaumidæ.

.1084 [Comment on Dr. Lamb's "Olecranon perforation."] *Amer.
April Anthropol.* Vol. III, 1890, p. 174.

.1085 [The Yellowstone Park.] *Amer. Nat.* Vol. XXIV, 1890,
April pp. 255, 256.
3 Unsigned editorial. Cited by Frazer.

.1086 New Hand-books of Paleontology. *Amer. Nat.* Vol. XXIV,
April 1890, pp. 259-261.
3 Review of: Elemente der Paleontologie, von Steinmann und
Döderlein, 1890: Handbuch der Paleontologie, Abth. 1, Band
III, Lief 3, Reptilien, von Prof. K. A. v. Zittel, 1889: Manual

of Paleontology for the use of Students, by R. A. Nicholson
and R. Lydekker, 2 vols., 1889.

.1087 Seeley's Researches on the Organization, Structure and
April Classification of the Fossil Reptilia. *Amer. Nat.* Vol. XXIV,
5 1889, pp. 271-273.
Critical review of: On *Protorosaurus speneri* von Meyer, Philos. Trans. Roy. Soc. 1887; On *Pariasaurus bombidens* Owen., Philos. Trans. Roy. Soc. 1888; On the Anomodont Reptiles and their Allies, Philos. Trans. Roy. Soc. 1889.

.1088 (Original Research in the United States.) *Amer. Nat.* Vol.
April XXIV, 1890, p. 358.
25 Unsigned editorial. Cited by Frazer.

.1089 Tortoises sold in the Markets of Philadelphia. *Amer. Nat.*
April Vol. XXIV, 1890, p. 374.
25

.1090 The Silver Lake of Oregon and its Region. *Amer. Nat.*
May Vol. XXIII, 1889, pp. 970-982, Pls. XL, XLI, and fig. 1.
10 Notes upon journey; recent fauna; Fossil Lake locality; list of fossil vertebrates.

.1091 (The Age of the Larami.) *Bull. Geol. Soc. Amer.* Vol. I,
May 1890, p. 532. *Amer. Nat.* Vol. XXIV, 1890, p. 569.
27 Certain remarks by Lester F. Ward, J. J. Stevenson and E. D. Cope at meeting of Geological Society of America.

.1092 The Homologies of the Fins of Fishes. *Amer. Nat.* Vol.
June XXIV, 1890, pp. 401-423, Pls. XIV-XVIII, figs. 1-9.
Relation of fins to legs, relation of fins to each other, nature of the supports of median fins, caudal fin and its supports.

.1093 (The Proposed Classes of the U. S. National Academy of
June Sciences.) *Amer. Nat.* Vol. XXIV, 1890, pp. 460, 461.
4 Unsigned editorial. Cited by Frazer.

.1094 (The Philadelphia Meeting of the International Congress of
June Geologists.) *Amer. Nat.* Vol. XXIV, 1890, pp. 461, 462.
4 Unsigned editorial. Cited by Frazer.

.1095 Scott and Osborn on the Fauna of the Brown's Park Eocene.
June *Amer. Nat.* Vol. XXIV, 1890, pp. 470-472.
4 Review of: The Mammalia of the Unita Formation, Pts. I, II by W. B. Scott; Pts. III, IV, by H. F. Osborn, Trans. Amer. Philos. Soc. Vol. XVI, 1889.

.1096 (The proposed National University.) *Amer. Nat.* Vol.
July XXIV, 1890, pp. 548, 549.
15 Unsigned editorial. Cited by Frazer.

.1097 (International Geological Congress.) *Amer. Nat.* Vol. XXIV,
July 1890, pp. 549-551.
15 Unsigned editorial. Cited by Frazer.

.1098 [Honest Nomenclature.] *Amer. Nat.* Vol. XXIV, 1890, p.
July 551.
15 Unsigned editorial. Cited by Frazer.

.1099 (Note on the "two-rooted" teeth described by Prof. Marsh.)
July *Amer. Nat.* Vol. XXIV, 1890, p. 571.
15 Teeth of Ceratopsia are not really two-rooted; the appearance is produced by absorption of centre of root above successional tooth. *Dysganus* Cope 1876 was based on Ceratopsian teeth.

.1100 The return of Negroes to Africa. *Open Court,* Vol. III,
July 1890, p. 2110; Vol. IV, 1890, p. 2331.
17

.1101 On Inheritance in Evolution. *Amer. Nat.* Vol. XXIII, 1889,
July pp. 1058-1071.
19 Exposition of theories of heredity.

.1102 [Original Scientific Research in the University of Pennsyl-
July vania.] *Amer. Nat.* Vol. XXIII, 1889, p. 1088.
19 Unsigned editorial. Cited by Frazer.

.1103 The Cetacea. *Amer. Nat.* Vol. XXIV, 1890, pp. 599-616,
Aug. Pls. XX-XXIII, figs. 1-8.
8 Synopsis of characters, affinities, classification and phylogeny, list of extinct American Cetacea.

.1104 The Extinct Sirenia. *Amer. Nat.* Vol. XXIV, 1890, pp. 697-
Sept. 702, Pls. XXV, XXVI, figs. 1-3.
3 Synopsis of families and genera; figures of some American forms.

.1105 [Reading Habits of the American Public.] *Amer. Nat.* Vol.
Sept. XXIV, 1890, pp. 747, 748.
3 Unsigned editorial. Cited by Frazer.

.1106 Eimer on Evolution. *Amer. Nat.* Vol. XXIV, 1890, pp. 751-
Sept. 754.
3 Review of: Organic Evolution as the Result of the Inheritance of Acquired Characters, according to the Law of Organic Growth, by G. E. T. Eimer, 1890.

.1107 Geddes and Thompson on the Evolution of Sex. *Amer. Nat.*
Sept. Vol. XXIV, 1890, pp. 754-760.
3 Review of: The Evolution of Sex, by Prof. Patrick Geddes and J. Arthur Thompson. Unsigned. Cited by Frazer.

.1108 Note on *Casteroides georguensis* Moore. *Amer. Nat.* Vol.
Sept. XXIV, 1890, p. 772.
3 Unsigned. Cited by Hay. Founded on a lower canine of
*Hippopotamus.*

.1109 Snakes in Banana Bunches. *Amer. Nat.* Vol. XXIV, 1890,
Sept. p. 782.
3

.1110 On the Material Relations of Sex in Human Society. *The*
Oct. *Monist,* Vol. I, 1890, pp. 38-47.

.1111 Newberry's Paleozoic Fishes of North America. *Amer. Nat.*
Oct. Vol. XXIV, 1890, pp. 844-847.
14 Critical review of: The Paleozoic Fishes of North America, by John Strong Newberry, Monograph XVI, U. S. Geol.
Survey, 1889.

.1112 The Evolution of Mind. *Amer. Nat.* Vol. XXIV, 1890, pp.
Nov. 899-913; 1000-1016.
8

.1113 [Limitation in Scientific Work.] *Amer. Nat.* Vol. XXIV,
Nov. 1890, p. 918-920.
8 Editorial.

.1114 (New York's Electric Execution Law.) *Amer. Nat.* Vol.
Nov. XXIV, 1890, p. 921.
8 Unsigned editorial. Cited by Frazer.

.1115 Poulton on the Colors of Animals. *Amer. Nat.* Vol. XXIV,
Nov. 1890, pp. 927-932.
8 Review of: The Colors of Animals, their Meaning and Use
especially considered in the case of Insects, by E. B. Poulton.
1890.

.1116 On Two New Species of Mustelidæ from the Loup Fork
Nov. Miocene of Nebraska. *Amer. Nat.* Vol. XXIV, 1890, pp.
8 950-952.
*Stenogale robusta* sp. and *Brachypsalis pachycephalus* gen.
et. sp. nov.

.1117 Note on a Bison at Syracuse, New York. *Amer. Nat.* Vol.
Nov. XXIV, 1890, p. 954.
8 =*Bos americanus.*

.1118 On a New Species of Salamander from Indiana. *Amer.*
Nov. *Nat.* Vol. XXIV, 1890, pp. 966, 967, figs. 1-7.
8 *Gyrinophilus maculicandus.*

.1119 The African in America. *Open Court,* Vol. IV, 1890, pp.
Dec. 2399-2401.

.1120 (Scientific Nomenclature.) *Amer. Nat.* Vol. XXIV, 1890,
Dec. pp. 1047-1049.
6 Unsigned editorial. Cited by Frazer.

.1121 On a New Dog from the Loup Fork Miocene. *Amer. Nat.*
Dec. Vol. XXIV, 1890, pp. 1067, 1068.
6 *Aelurodon compressus* n. sp. Based upon a lower jaw in the Cope Collection and two rami in Mus. Comp. Zool., referred by Scott and Osborn to *Ae. hyænoides* Cope. Figure of skeleton of *Ae. saevus* in Cope Coll.

1891.1122 On Vertebrata from the Tertiary and Cretaceous Rocks of the North West Territory. I—The Species from the Oligocene or Lower Miocene Beds of the Cypress Hills. *Contrib. to Canadian Pal.* Vol. III, pp. 1-25, Pls. I-XIV.

*Amia whiteavesiana, A. macrospondyla.; Rhineastis rhæas; Amiurus cancellatus, A. maconnellii*: all new species.

.1123 Report of the Sub-Committee on the Cenozoic (Interior): Reports of the American Sub-Committees on Classification and Nomenclature (E. D. Cope, Reporter). *Congrès Géol. Internat.* 4*e* Sess. Londres, 1888, Appendix A, pp. A193-A210. (Published 1891).

.1124 (The Tariff on Scientific Books.) *Amer. Nat.* Vol. XXIV,
Jan. 1890, pp. 1169, 1170.
9 Unsigned editorial. Cited by Frazer.

.1125 Dr. Leonhard Stejneger on *Bufo lentiginosus woodhousei.*
Jan. *Amer. Nat.* Vol. XXIV, 1890, pp. 1204, 1205.
9

.1126 On Two New Perissodactyles from the White River Neocene.
Feb. *Amer. Nat.* Vol. XXV, 1891, pp. 47-49.
21 *Menodus peltoceras, Cænopus simplicidens,* n. sp. (Types now in Amer. Mus.)

.1127 Discovery of Fish Remains in Ordovician Rocks. *Amer.*
Feb. *Nat.* Vol. XXV, 1891, p. 137.
21 Unsigned. Cited by Hay. Notice of Walcott's preliminary announcement before Biol. Soc. Washington, Feb. 7, 1891.

.1128 Material Relations of Sex in Human Society. *Open Court*
March Vol. V, No. 187, March 26, 1891, p. 2748.
26

.1129 The Epiglottis in Colubrine Snakes. *Amer. Nat.* Vol. XXV,
April 1891, pp. 156, 157, one fig.
2

.1130 Professor Moll on Hypnotism. *Amer. Nat.* Vol. XXV, 1891,
April pp. 170, 171.
2 Review of: Hypnotism, by Albert Moll, 1890.

.1131 The Economic Relations of Sex. *Open Court* Vol. V,
May No. 193, May 7, 1891, pp. 2801, 2802.
7

.1132 (New National Parks.) *Amer Nat.* Vol. XXV, 1891,
May pp. 472, 473.
28 Unsigned editorial. Cited by Frazer.

.1133 On the Non-Actinopterygian Teleostomi. *Amer. Nat.* Vol.
May XXV, 1891, pp. 479-481.
28 Short discussion followed by a table giving superorders, orders, and families to show relationships.

.1134 [Prof. Karl Vogt and the Naturalists.] *Amer. Nat.* Vol.
June XXV, 1891, pp. 558, 559.
27 Editorial.

.1135 On the Structure of Certain Paleozoic Fishes. *Proc. A. A.*
July *A. S.* XXXIX Meeting, 1890, p. 336.
*Macropetalichthys, Megalichthys, Platysomus* and *Dendrodus* briefly considered.

.1136 The Relation of Mind to its Physical Basis. *Proc. A. A.*
July *A. S.* XXXIX Meeting, 1890, p. 378.
Abstract only.

.1137 Syllabus of Lectures on Geology and Paleontology. Part
July III—Paleontology of the Vertebrata. Ferris Bros., Phila-
8 delphia, 8vo., 1891, 90 pp., 60 figs.
See also 1390.

.1138 [Preoccupied Names.] *Amer. Nat.* Vol. XXV, 1891, pp. 640,
July 641.
31 Unsigned editorial. Cited by Frazer. Objection regarding *Menodus* as preoccupied by *Menodon*.

.1139 Catalogue of the Fossil Reptilia and Batrachia (Amphibia)
July in the British Museum, Parts II, III and IV. *Amer. Nat.*
31 Vol. XXV, 1891, pp. 644-646.
Review of: Catalogue of the Fossil Reptilia and Amphibia in the British Museum, by Richard Lydekker, Part II, 1889, Part III, 1889, Part IV, 1890. Criticism of classification and nomenclature adopted.

.1140 A. S. Woodward's Fossil Fishes. *Amer. Nat.* Vol. XXV,
July 1891, pp. 646, 647.
31 Review of: Catalogue of Fossil Fishes in the British Museum, by Arthur Smith Woodward, Part I, 1889; Part II, 1891.

.1141 July 31 Mrs. Bodington on Evolution. *Amer. Nat.* Vol. XXV, 1891, p. 647.

Review of: Studies in Evolution and Biology, by Alice Bodington, 1890.

.1142 July 31 On some New Fishes from South Dakota. *Amer. Nat.* Vol. XXV, 1891, pp. 654-658. Read under title, "On a New Horizon of Fossil Fishes," before the A. A. A. S. XL Meeting, 1891. Abstract only, Proc. A. A. A. S. XL Meeting, 1891, p. 258.

*Gephyrura, Proballostomus,* new genera described, three species from Tertiary of Ree Hills, S. D.

.1143 Sept. 11 The Liptoterna. *Amer. Nat.* Vol. XXV, 1891, pp. 685-693, Pl. XVII, figs. 1-5.

Discussion of characters and affinities; synopsis of families and genera. Astrapotherium and Homalodontotherium provisionally included. Based largely on Ameghino's "Mamiferos Fosiles de la Republica Argentina."

.1144 Sept. 11 Anent Women's Waists. *Amer. Nat.* Vol. XXV, 1891, pp. 717, 718.

Editorial.

.1145 Sept. 11 (Marine Biological Laboratories.) *Amer. Nat.* Vol. XXV, 1891, pp. 718-721.

Unsigned editorial. Cited by Frazer.

.1146 Sept. 11 (Execution by Electricity.) *Amer. Nat.* Vol. XXV, 1891, pp. 721, 722.

Unsigned editorial.

.1147 Sept. 11 Ameghino on the Extinct Mammalia of Argentina. *Amer. Nat.* Vol. XXV, 1892, pp. 725-727.

Review of: Contribucion al concimento de los mamiferos fosiles de la Republica Argentina . . . por Florintino Ameghino. Actes, Acad. nacional ciencias, Cordoba, T. VI, 1889.

.1148 Sept. 11 Miller's North American Geology and Paleontology. *Amer. Nat.* Vol. XXV, 1891, p. 729.

Review of: American Geology and Paleontology for the Use of Amateur Students and Scientists, by S. A. Miller, 1889. Unsigned. Cited by Frazer.

.1149 Sept. 11 Morris on Civilization. *Amer. Nat.* Vol. XXV, 1891, p. 730.

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6 Review of: Catalogue of the Chelonians, Rhynchocephalians and Emydosaurians in the British Museum, by G. A. Boulenger, 1889.

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.1154 (Tariff on Scientific Works.) *Amer. Nat.* Vol. XXV,
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17 Unsigned editorial. Cited by Frazer.

.1155 [Recent Progress in the Discovery of the Phylogeny of
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17 Editorial. Notice of Spy discoveries in Belgium, and *Homunculus* in Patagonia.

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17 Description, with figures, of *Arctotherium simum* skull.

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17 Comment on Ameghino's discoveries.

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12 XXXIII.
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.1160 (Recent Endowments for Scientific Research.) *Amer. Nat.*
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22 Review of: An Introduction to the Study of Mammals, Living and Extinct, by W. H. Flower and R. Lydekker, 1891.

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5 474-478.

.1166 Alfred Russell Wallace. *Brooklyn Ethical Assoc., Evolution*
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March XXVI, 1892, pp. 49, 50.
26 Pliocene: Blanco formation.

.1168 Definite vs. Fortuitous Variation in Animals and Plants.
March *Amer. Nat.* Vol. XXVI, 1892, pp. 89-91.
26 Abstract of remarks before Amer. Soc. of Naturalists, Dec. 30, 1891.

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28 XIV, 1892, pp. 589-694.

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March *Proc. Amer. Philos. Soc.* Vol. XXX, 1892, pp. 123-131,
30 one fig. Reprint, "Report on the Palæontology of the Vertebrata," *Third Ann. Report, Geol. Survey, Texas,* 1891, pp. 251-259.

.1171 On *Tiaporus,* a New Genus of Teiidæ. *Proc. Amer. Philos.*
March *Soc.* Vol. XXX, 1892, pp. 132, 133, one plate.
30

.1172 On the Habits and Affinities of the new Australian Mammal,
March *Notoryctes typhlops.* *Amer. Nat.* Vol. XXVI, 1892, pp.
31 121-128, Pls. IX, X.
Extracts from Stirling's memoir describing Notoryctes.

Trans. R. Soc. S. Austr., 1891, vol. xiv. Discussion of affinities. Regards it as more probably related to Chrysochloridæ.

Cope's genus *Bematiscus* established in a footnote to p. 127.

.1173 [Mongoose in the West.] *Amer. Nat.* Vol. XXVI, 1892,
April p. 236.
25 Unsigned editorial. Cited by Frazer.

.1174 On the Homologies of the Posterior Cranial Arches in the
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27 pp. 11-26, Pls. I-V and figs. 1-3. Separates April 27, 1892.
Abstract, "The Homologies of the Cranial Arches of the
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XV-XVII.

.1175 [Rational Nomenclature.] *Amer. Nat.* Vol. XXVI, 1892,
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29 Unsigned editorial. Cited by Frazer.

.1176 Professor Marsh on Extinct Horses and Other Mammalia.
May *Amer. Nat.* Vol. XXVI, 1892, pp. 410-412.
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Marsh, Amer. Journ. Sci., 1892, p. 339; and, A New Order of
Extinct Mammalia, by O. C. Marsh, Amer. Journ. Sci., 1892,
p. 445.

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4 27-52, Pls. VI-XIII. Separates May 4, 1892. Abstract,
"Parallel Color-Patterns in Lizards," *Amer. Nat.* Vol. XXVI,
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May *Proc. Amer. Philos. Soc.* Vol. XXX, 1892, pp. 221-229, Pls.
24 VII, VIII.

.1180 On the Skull of the Dinosaurian *Lælaps incrassatus* Cope.
May *Proc. Amer. Philos. Soc.* Vol. XXX, 1892, pp. 240-245.
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.1181 Remarks on the communication, "Ein fossiler Giftzahn," by
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13 s. 224.

.1182 On Color Variations in certain Reptilia. *Proc. A. A. A. S.*,
July XL Meeting, 1891, pp. 320, 321.

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.1185 Aug. 23 A Contribution to a Knowledge of the Blanco Beds of Texas. *Proc. Acad. Nat. Sci. Phila.* Vol. XLIV, 1892, pp. 226-229. Abstract, "The Cenozoic Beds of the Staked Plains of Texas," *Proc. A. A. A. S.*, XLI Meeting, 1892, p. 177.

.1186 Sept. Fourth Note on the Dinosauria of the Laramie. *Amer. Nat.* Vol. XXVI, 1892, pp. 756-758.

*Manospondylus* and *Claorhynchus*, new genera. Notes on *Agathaumas* based upon complete skeleton found by J. L. Wortman in South Dakota (subsequently referred to Hadrosaurus = Trachodon).

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Description of *Thlæodon padanicus* gen. et sp. nov.

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.1189 Nov. On Degenerate Types of Scapular and Pelvic Arches in the Lacertilia. *Journ. Morph.* Vol. VII, 1892, pp. 223-244, Pl. XIII.

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.1190 Nov. 1 [Man's Powers of Observation.] *Amer. Nat.* Vol. XXVI, 1892, p. 931.

Unsigned editorial. Cited by Frazer.

.1191 Nov. 1 Crook on Saurodontidæ from Kansas. *Amer. Nat.* Vol. XXVI, 1892, pp. 941, 942.

Critical review of: Ueber einige fossile Knochenfische der Mittleren Kreide von Kansas, von Alja Robinson Crook, Palæontographica, Bd. XXXIX, 1892, s. 107.

.1192 Nov. 1 A New Species of *Eutænia* from Western Pennsylvania. *Amer. Nat.* Vol. XXVI, 1892, pp. 964, 965, one fig.

*Eutænia brachystoma.*

.1193 Nov. 29 On the Permanent and Temporary Dentitions of certain Three-toed Horses. *Amer. Nat.* Vol. XXVI, 1892, pp. 942-944, Pls. XXV, XXVI. *Proc. Acad. Nat. Sci. Phila.* Vol. XLIV, 1892, pp. 325, 326.

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.1194 A Hyaena and other Carnivora from Texas. *Proc. Acad.*
Nov. *Nat. Sci. Phila.* Vol. XLIV, 1892, pp. 326, 327. Reprint,
29 *Amer. Nat.* Vol. XXVI, 1892, pp. 1028, 1029.
*Borophagus* a hyaena, *Canimartes* a new musteline, *Felis hillanus* (earliest true cat in North America).

.1195 The Batrachia and Reptilia of Northwestern Texas. *Proc.*
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29 Collection from the Staked Plains.

.1196 American Devonian Fishes in Belgium. *Amer. Nat.* Vol.
Nov. XXVI, 1892, p. 1025.
29 Notice of a paper by M. Lohest in Ann. Soc. geol. de Belgique, T. XVI, p. lvii. Unsigned. Cited by Hay.

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Jan. brates. *Proc. Amer. Philos. Soc.* Vol. XXX, 1892, pp. 282-
3 285.

.1200 On False Elbow Joints. *Proc. Amer. Philos. Soc.* Vol. XXX,
Jan. 1892, pp. 285-291, Pls. IX, X.
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.1201 [The Antivivisectionists in Pennsylvania.] *Amer. Nat.* Vol.
Jan. XXVII, 1893, p. 26.
11 Unsigned editorial. Cited by Frazer.

.1202 [The Law of Priority in Nomenclature.] *Amer. Nat.* Vol.
Feb. XXVII, 1893, pp. 134, 135.
4 Unsigned editorial. Cited by Frazer.

.1203 A Remarkable Artiodactyle from the White River Epoch.
Feb. *Amer. Nat.* Vol. XXVII, 1893, pp. 147, 148, Pls. I, II.
4 Review of Osborn's and Wortman's description of *Protoceras celer* in Bull. Amer. Mus. Nat. Hist. Vol. IV, 1892, pp. 359-372.

.1204 On a New Spade-Foot from Texas. *Amer. Nat.* Vol.
Feb. XXVII, 1893, pp. 155, 156.
4 *Spea laticeps.*

.1205 [The Geological Survey of Illinois.] *Amer. Nat.* Vol.
March XXVII, 1893, p. 238.
4 Unsigned editorial. Cited by Frazer.

.1206 [Mortality of the English Sparrow.] *Amer. Nat.* Vol.
March XXVII, 1893, p. 239.
4 Unsigned editorial. Cited by Frazer.

.1207 Correlation Papers of the U. S. Geological Survey—Neocene.
March *Amer. Nat.* Vol. XXVII, 1893, pp, 246-248.
4 Review of: Bulletin, U. S. Geol. Survey No. 84—Correlation Papers Neocene, by W. H. Dall and G. D. Harris, 1892. Unsigned. Cited by Frazer.

.1208 Cary on the Evolution of Foot Structure. *Amer. Nat.*
March Vol. XXVII, 1893, pp. 248-250.
4 Review of: A Study in Foot Structure, by Austin Cary, Amer. Journ. Morph., Dec., 1892, p. 305.

.1209 Earle on the Species of Coryphodontidæ. *Amer. Nat.* Vol.
March XXVII, 1893, pp. 250-252.
4 Critical review of: Revision of the Species of *Coryphodon*. Bull. Amer. Museum Nat. Hist., Vol. IV, Art. XII, pp. 149-166, Oct. 18, 1892. Takes exception to Earle's reduction of many species to synonymy.

.1210 The Vertebrate Fauna of the Ordovician of Colorado. *Amer.*
March *Nat.* Vol. XXVII, 1893, pp. 268, 269.
4 Unsigned. Cited by Hay. Review of Walcott's article in Bull. Geol. Soc. Amer. Vol. III, pp. 153-172.

.1211 A New Extinct Species of Cyprinidæ. *Proc. Acad. Nat.*
March *Sci. Phila.* Vol. XLV, 1893, pp. 19, 20. *Aphelichthys lindahlii*
14 N. Sp. from Pulaski Co., Illinois.

.1212 The Lynching at Paris, Texas. *Open Court* Vol. VII, No.
March 291, March 23, 1893, p. 3606.
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.1213 The Genealogy of Man. *Amer. Nat.* Vol. XXVII, 1893,
April pp. 321-335, Pl. IX, and figs. 1-9.
5 Discusses derivation of man and anthropoid apes from Eocene Lemuroidea, the monkeys and the modern lemurs being both side branches; characters of the Spy race (Neanderthaloids).

.1214 [Book Publication in America.] *Amer. Nat.* Vol. XXVII,
April 1893, p. 359.
5 Unsigned editorial. Cited by Frazer.

.1215 Animal Coloration. *Amer. Nat.* Vol. XXVII, 1893, pp. 371-
April 374, figs. 1-3.
5 Review of: Animal Coloration, an Account of the Principal
Facts and Theories relating to the Colors and Markings of
Animals, by Frank E. Beddard, 1892. Unsigned. Under
Cope in index of volume.

.1216 Fossil Reptiles from the Parana. *Amer. Nat.* Vol. XXVII,
April 1893, pp. 376, 377.
5 Comment on Ambrosetti's article in Boletin, Acad. nacional de Ciencias, Cordoba.

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April *Proc. Acad. Nat. Sci. Phila.* Vol. XLVI, 1893, pp. 181-184.
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.1218 A Preliminary Report on the Vertebrate Palæontology of
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Texas,* 1892, pp. 1-89, Pls. I-XXIII. Separates, May, 1893.
Abstract, "The Vertebrate Palæontology of the Llano
Estacado," *Amer. Nat.* Vol. XXVII, 1893, pp. 811-812.

.1219 Description of the Lower Jaw of *Tetrabelodon shepardii*
May Leidy. *Proc. Acad. Nat. Sci. Phila.* Vol. XLV, 1893, pp.
23 202-204. Abstract, *Amer. Nat.* Vol. XXXVII, 1893, p. 473.

.1220 [The Geological Survey of Georgia.] *Amer. Nat.* Vol.
May XXVII, 1893, p. 450.
25 Unsigned editorial. Cited by Frazer.

.1221 [The Exhibition of Monstrosities.] *Amer. Nat.* Vol.
May XXVII, 1893, pp. 450, 451.
25 Unsigned editorial. Cited by Frazer.

.1222 Prodromus of a New System of the Non-venomous Snakes.
May *Amer. Nat.* Vol. XXVII, 1893, pp. 477-483.
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.1223 Evolution of the Colors of North American Land Birds.
June *Amer. Nat.* Vol. XXVII, 1893, pp. 547-549.
15 Review of: Evolution of the Colors of North American
Land Birds by Charles A. Keeler, Occasional papers, Calif.
Acad. Sci., III, 1893.

.1224 Wright's Man and the Glacial Period. *Amer. Nat.* Vol.
June XXVII, 1893, pp. 550-553.
15 Review of: Man and the Glacial Period, by G. Frederick
Wright, 1892.

.1225 A Supposed New Order of Gigantic Fossils from Nebraska.
June *Amer. Nat.* Vol. XXVII, 1893, pp. 559, 560.
15 *Daimonelix.* Review of article by E. H. Barbour. These
objects are regarded by Cope as rodent burrows.

.1226 The Foundations of Theism. *The Monist* Vol. III, 1893,
July pp. 623-639.

.1227 Calderwood on Mental Evolution. *Amer. Nat.* Vol. XXVII,
July 1893, pp. 654, 655.
24 Review of: Evolution and Man's Place in Nature, by Henry Calderwood, 1893.

.1228 The Relation of Consciousness to its Physical Basis. *Religo-*
Sept. *Philosophical Journ.* n. s. Vol. IV, 1893, pp. 293, 294.
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.1229 The Effeminization of Man. *Open Court* Vol. VII, Oct. 26,
Oct. 1893, p. 3847.
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.1230 [The Field Museum of Chicago.] *Amer. Nat.* Vol. XXVII,
Oct. 1893, p. 886.
31 Unsigned editorial. Cited by Frazer.

.1231 [Duplication of Names of Post Offices.] *Amer. Nat.* Vol.
Oct. XXVII, 1893, pp. 886, 887.
31 Unsigned editorial. Cited by Frazer.

.1232 A New Pleistocene Saber-tooth. *Amer. Nat.* Vol. XXVII,
Oct. 1893, pp. 896, 897.
31 *Dinobastis serus* gen. et sp. nov. from Pleistocene of Oklahoma.

.1233 [Specimens in the Mails.] *Amer. Nat.* Vol. XXVII, 1893,
Oct. pp. 979, 980.
31 Unsigned editorial. Cited by Frazer.

.1234 [The Pronunciation of Arkansas.] *Amer. Nat.* Vol. XXVII,
Oct. 1893, pp. 980, 981.
31 Unsigned editorial. Cited by Frazer.

.1235 The Report of the Death Valley Expedition. *Amer. Nat.*
Oct. Vol. XXVII, 1893, pp. 990-995.
31 Review of: The Death Valley Expedition: A Biological Survey of Parts of California, Nevada, Arizona and Utah, Part II. North American Fauna, No. 7, 1893.

.1236 On *Symmorium,* and the Position of the Cladodont Sharks.
Nov. *Amer. Nat.* Vol. XXVII, 1893, pp. 999-1001.
24 On basis of pectoral fin structure, Cladodontidae are removed from Ichthyotomi and placed among the Acanthodii.

.1237 Forsyth Major and Rose on the Theory of Dental Evolution.
Nov. *Amer. Nat.* Vol. XXVII, 1893, pp. 1014-1016.
24 Critical comment on recent articles by these writers.

.1238 Dec. 7 On the Genus *Tomiopsis*. *Proc. Amer. Philos. Soc.* Vol. XXXI, 1893, pp. 317, 318.

.1239 Dec. 13 The Color Variations of the Milk Snake. *Amer. Nat.* Vol. XXVII, 1893, pp. 1066-1071, Pls. XXIV-XXVIII.

.1240 Dec. 13 [College and University Publications.] *Amer. Nat.* Vol. XXVII, 1893, p. 1072.

Unsigned editorial. Cited by Frazer.

.1241 Dec. 13 Fritsch's Fauna of the Gaskohle of Bohemia. *Amer. Nat.* Vol. XXVII, 1893, pp. 1079-1081, Pls. XXIX, XXX and one fig.

Critical review of: Fauna der Gaskohle und Kalkstein der Permformations Böhmes von Anton Fritsch, Band II, Heft 4, 1889; Band III, Hefts I and II, 1893.

.1242 Dec. 13 Cladodont Sharks of the Cleveland Shale. *Amer. Nat.* Vol. XXVII, 1893, p. 1083.

Unsigned. Cited by Hay. Review of Claypole's paper in Amer. Geol., May, 1893.

.1243 Dec. 23 Second Addition to the Knowledge of the Batrachia and Reptilia of Costa Rica. *Proc. Amer. Philos. Soc.* Vol. XXXI, 1893, pp. 333-347.

1894.1244 Jan. 25 On Three New Genera of *Characinidæ*. *Amer. Nat.* Vol. XXVIII, 1894, p. 67.

*Asiphonichthys, Chorimycterus, Diapoma,* from upper Jacuhy R., Rio Grande do Sul, Brazil.

.1245 Jan. 30 On a collection of Batrachia and Reptilia from Southwest Missouri. *Proc. Acad. Nat. Sci. Phila.* Vol. XLV, 1893, pp. 383-385.

Ozark Mountain country.

.1246 Jan. 30 On the Batrachia and Reptilia of the Plains at Latitude 36° 30'. *Proc. Acad. Nat. Sci. Phila.* Vol. XLV, 1893, pp. 386, 387.

.1247 Jan. 30 Fossil Fishes from British Columbia. *Proc. Acad. Nat. Sci. Phila.* Vol. XLV, 1893, pp. 401, 402.

*Amyzon brevipinne* N. Sp.

.1248 Feb. 27 Heredity in the Social Colonies of the Hymenoptera. *Proc. Acad. Nat. Sci. Phila.* Vol. XLV, 1893, pp. 436-438.

.1249 March 3 On the Fishes obtained by the Naturalist Expedition in Rio Grande do Sul. *Proc. Amer. Philos. Soc.* Vol. XXXIII, 1894, pp. 84-108, Pls. IV-IX.

Forty-two species listed, mainly Characinidae (3 new genera and 9 new species), Siluridae (6 new species), and Cichlidae (2 new species).

.1250 March 6 On the Structure of the Skull in the Plesiosaurian Reptilia, and on Two New Species from the Upper Cretaceous. *Proc. Amer. Philos. Soc.* Vol. XXXIII, 1894, pp. 109-113, Pl. X, one fig. Separates March 6, 1894.

.1251 March 8 The Energy of Evolution. *Amer. Nat.* Vol. XXVIII, 1894, pp. 205-219.

.1252 March 8 An Examination of Weismannism. *Amer. Nat.* Vol. XXVIII, 1894, pp. 257-259.

Review of: An Examination of Weismannism, by George John Romanes, 1893.

.1253 March 8 Extinct Monsters. *Amer. Nat.* Vol. XXVIII, 1894, pp. 259-262, figs. 1, 2.

Review of: Extinct Monsters. A popular Account of some of the Larger Forms of Ancient Animal Life, by Rev. H. N. Hutchinson, 1893.

.1254 May The Origin of Structural Variations. *New Occasions* Vol. II, No. 6, 1894, pp. 273-299.

.1255 May 4 [City Parks.] *Amer. Nat.* Vol. XXVIII, 1894, p. 399.

Unsigned editorial. Cited by Frazer.

.1256 May 4 [On Madagascariensis.] *Amer. Nat.* Vol. XXVIII, 1894, pp. 399, 400.

Unsigned editorial. Cited by Frazer.

.1257 May 4 [Note on Rohon's term "Aspidocephali."] *Amer. Nat.* Vol. XXVIII, 1894, p. 414.

.1258 May 4 On the Iguanian Genus *Uma* Baird. *Amer. Nat.* Vol. XXVIII, 1894, pp. 434, 435, figs. 1-4.

Two species described from Tucson, Arizona.

.1259 May 4 On the Genera and Species of *Euchirotidæ*. *Amer. Nat.* Vol. XXVIII, 1894, pp. 436, 437, figs. 5, 6.

Three Mexican genera distinguished.

.1260 May 29 Observations on the Geology of Adjacent Parts of Oklahoma and Northwest Texas. *Proc. Acad. Nat. Sci. Phila.* Vol. XLVI, 1894, pp. 63-68.

.1261 New and Little Known Paleozoic and Mesozoic Fishes.
May *Journ. Acad. Nat. Sci. Phila.* Ser. 2 Vol. IX, 1894, pp.
31 427-448, Pls. XVIII-XX; figs. 1-5. Separates May 31, 1894.
Sharks of the genera *Symmorium, Orodus* (*basalis* N. Sp.), *Styptobases* (*aculata* N. Sp.), *Dittodus* (*planidens* N. Sp.); Teleostome genus *Megalichthys;* Crossopterygian genus *Macrepistius carenatus* N. Gen. et Sp.; Pycnodontid genera *Mesodon* (*diastematicus* N. Sp.), *Uranoplosus* (*arctatus* and *flectidens* N. Sp.), and *Coelodus* (*braconii* N. Sp.).

.1262 On *Cyphornis,* an Extinct Genus of Birds. *Journ. Acad. Nat.*
May *Sci. Phila.* Ser. 2 Vol. IX, 1894, pp. 449-452. Separates
31 May 31, 1894.

.1263 Extinct *Bovidæ, Canidæ* and *Felidæ* from the Pleistocene of
May the Plains. *Journ. Acad. Nat. Sci. Phila.* Ser. 2, Vol. IX,
31 1894, pp. 453-459, Pls. XXI, XXII. Separates May 31, 1894.

.1264 [The U. S. National Academy of Sciences.] *Amer. Nat.*
June Vol. XXVIII, 1894, pp. 494, 495.
1 Unsigned editorial. Cited by Frazer.

.1265 [The Proposed National Academy of Science and Art.]
June *Amer. Nat.* Vol. XXVIII, 1894, pp. 495, 496.
1 Unsigned editorial. Cited by Frazer.

.1266 The Proposed Division of the National Academy of Sciences.
June *Amer. Nat.* Vol. XXVIII, 1894, pp. 553, 554.
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.1267 The Oppression of Women. *Open Court* Vol. VIII, No.
June 354, June 7, 1894, pp. 4103-4105.
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.1268 The Youthful Reporter. *Open Court* Vol. VIII, No. 355,
June June 14, 1894, pp. 4113, 4114.
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.1269 On the Lungs of Ophidia. *Proc. Amer. Philos. Soc.* Vol.
June XXXIII, 1894, pp. 217-224, Pls. XI-XVI.
26 Abstract, "The Pulmonary Structures of the Ophidia," *Proc. A. A. A. S.* XLIII Meeting, 1894, p. 254.

.1270 Schlosser on American Eocene *Vertebrata* in Europe. *Amer.*
July *Nat.* Vol. XXVIII, 1894, pp. 594, 595.
13 Review of: Bemerkungen zu Rütimeyer's "eocäne Säugethierwelt von Egerkingen," von Max Schlosser, Zoolog. Anzeiger, Bd. XVII, s. 157-162. Unsigned. Cited by Hay.

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These plates were prepared under Professor Cope's direction about 1881-3 to illustrate the final volumes of his reports on fossil vertebrates for the Hayden Survey (U. S. Geol. and Geogr. Survey of the Territories) which were never published. The titles appear on the plates, but no manuscript or plate descriptions pertaining to them were found among Professor Cope's papers. The joint publication of the plates as specified in the title was arranged through the efforts of Professor Henry Fairfield Osborn. Nearly all the specimens illustrated are in the Cope Collection, American Museum of Natural History.

NATIONAL ACADEMY OF SCIENCES
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BIOGRAPHICAL MEMOIRS
VOLUME XIV—FOURTH MEMOIR

# BIOGRAPHICAL MEMOIR

OF

# JOHN MERLE COULTER
1851-1928

BY

WILLIAM TRELEASE

PRESENTED TO THE ACADEMY AT THE AUTUMN MEETING, 1929

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# JOHN MERLE COULTER

## November 20, 1851—December 23, 1928

BY WILLIAM TRELEASE

Heredity and environment both contributed to making John Coulter what he became. He was born at Ningpo, in China, where his parents were engaged in religious missionary work. Widowed when he was only two years old, his mother returned to her earlier home in Hanover, Indiana, where her two sons—for his younger brother, Stanley, also had been born in Ningpo—grew up tutored and precepted by a cultured mother and stimulated by attractive and refining surroundings.

Among American botanists who have achieved distinction he falls on the transition line between those to whom preparation for earning a livelihood lay apart from training in botany as a vocation, and those to whom such training is professional. Liberally rather than specially educated, he had found himself in the field of his life work before obtaining the doctorate in philosophy, which is considered the open sesame to preferment in academic circles today though it was all but unknown among American botanists when his work began. His own scholarship was stamped with the academic approval of Hanover College, which gave him the bachelor's degree in 1870 and the master's degree in 1873, and of the University of Indiana, from which he won the degree of doctor of philosophy in 1882 and received the honorary doctorate of laws in 1920.

Coulter was richly endowed by nature for a successful career as an educator. An impressively large and comely man, he demonstrated early his unusual talent for clear analysis and clean-cut presentation of subject-matter, which, though normally free from polemics and personal criticism, neatly disposed of contradictory opinions and left in the minds of his hearers that sense of finality dear to the student hearer; and his was the rare faculty of holding the reins of the teacher with that combined firmness and gentleness which guides without any sense of compulsion, so that from the earliest to the latest those of his students who survive him hold him in affectionate as well as reverential memory.

One of the most evasive as well as most significant points in every successful life is that at which a life-passion appears. This turning point in John Coulter's case came in his senior year at Hanover College, when—as Mrs. Coulter has written charmingly—a young man came to the campus to teach the natural sciences, Professor E. Thomson Nelson, who "had a lively interest in hunting down the flowers about the lovely surrounding hills. John was his almost constant companion, and, as he seemed to be equally interested in everything he studied, became for the time being a 'botany fiend' ": to this localized first interest, it may be remembered, he returned frequently in later years. Those of us who knew him in later life were aware that he limped slightly in walking. Through his college life this impediment, resulting from a very serious wound in one knee, seems to have been far greater, and his field activities are the more noteworthy because at this time he was compelled to use crutches and was neither strong nor with that evidence of sturdy health familiar to those who knew him later.

To Dr. Frank H. Bradley, Nelson's predecessor at Hanover, and at that time his preceptor in geology, is credited the start toward health and fame in Coulter's life. Bradley was appointed by Hayden when the United States Geological Survey was organized in 1872 and he gave Coulter an opportunity to go into the field with him as an assistant in geology—an outing that returned him to the haunts of men permanently reconstituted.

Well schooled, he had begun his teaching career, immediately after graduation, in a girl's school at Logansport, Indiana, associated with his mother, where he taught Latin nominally, with incidental inclusion of "Greek or any study that needed a teacher." Knowing his educational environment, it is easy to see how easy the transition was from the Latinist to the geologist. The conversion of the geologist into the botanist is as clearly forecast in the same knowledge—given only the opportunity.

Some of those who have heard Coulter lecture on his early western experiences have heard him explain, whimsically, that this opportunity came through his inability to play cards.

The story is that whatever tasks he may have performed as a geologist-assistant on the Survey, he could not refrain from collecting the odd plants—very unlike those of the Mississippi Valley—that he found in this "Far West." When the daytime activities of the organizing field party were ended, Coulter found his evening diversion in giving to plants picked up here and there through the day that affectionate looking-over that every real botanist knows to be the prime reason for putting them in press. One evening when he was thus trifling with his specimens while his companions were engaged in the more generally interesting pastime of a social game, a voice from over his shoulder inquired what sort of a game of solitaire *that* was. This was early in the season, at Ogden, Utah, and the voice belonged to Hayden, who had dropped in unannounced, and who had the good sense to harness in an unrepresented field the enthusiast that fate had played into his hands, even though he could not cripple the geological side of the Survey by relieving him from the work for which his original appointment was made.

The immediate result of the opportunity this gave Coulter may be read in the published results of his work on the Hayden survey; a "Synopsis of the Flora of Colorado," prepared in collaboration with Professor T. C. Porter (1874), and a report on the botany of Montana, Idaho, Wyoming and Utah (1875).

For Coulter, himself, the opportunity meant much more than this, and its fruits were far-reaching. Critical study of a flora very different from that of the Eastern States necessarily brought the young botanist into correspondence and personal relations with the eminent botanists of the day, whose friendly aid continued so long as they lived.

Out of the Colorado synopsis grew a formal "Manual of the Botany of the Rocky Mountain Region" (1885), modeled—like Chapman's "Manual for the Southern States"—largely after Asa Gray's masterly "Manual for the Northeastern States"; and this Rocky Mountain manual was brought more nearly to completeness in editorial cooperation with Aven Nelson a quarter century later.

The welcome accorded this Rocky Mountain manual, with its short diagnostic descriptions which included, as Coulter once phrased it when speaking of another book of the kind, "enough but not too much"—seems to have inspired the idea of putting into similar form an account of the plants of the Mississippi Valley and of the plains, in large part omitted from his own work, from its often revised prototype—Gray's manual, and from the already antiquated southern manual of Chapman for which demand had become so slight as seemingly to warrant only inadequate supplements instead of a thorough revision.

The scope of such a work fell too close to the natural limits of both of these books, and Coulter was drawn into consultation with publishers and author concerning an extended and modernized edition of Professor Gray's manual, in the preparation of which Coulter should cooperate and bear the brunt of the labor. Incorporation of the South proved quite too large an undertaking for a handbook of the approved size and cost; but within their own parallels it had been virtually decided that the Rocky Mountain and eastern floras should be brought together by a westward extension of range for the new edition of Gray's manual. Professor Gray's death ended the original plan but a less critical revision on much the same geographic lines was undertaken and carried through by Sereno Watson and Coulter with a methodical promptness which possibly would not have been possible if Dr. Gray had lived. The significance of this statement perhaps will appear to those who have used successively the last of the editions of this manual prepared by its author, the revision within strict limitations of size by Watson and Coulter, and the latest and very different edition, by Robinson and Fernald, which followed in due time. Quite apart from obvious new discoveries in even the well explored East, formal segregations in what had passed for species were claiming recognition, and Eichler's views on classification were affecting the sequencing of plant families.

It was here that Coulter entered upon a second evolutionary stage as a systematist—that of the monographer; for when the revision of the eastern manual was under discussion he had progressed far in a critical analysis of the North American Hypericaceae; and a comparable study of our Umbelliferae, in conjunction with his most productive student in the systematic field, J. N. Rose, was well under way before the new manual had been brought to a conclusion. In the same line of study, and similarity as a guiding senior author, Coulter successively worked our Cornaceae, Amaranthaceae and part of the Cactaceae, recurring from time to time to each group as new discoveries or interpretations prompted; and in conjunction with Rose he was tempted into a further investigation of leaf anatomy as a taxonomic and diagnostic guide in certain Coniferae for which Engelmann had somewhat more than broken the way.

Coulter's talent for seizing and epitomizing succinctly the high points of specific characters, which Asa Gray's writings had made a second nature with him as with many others, brought to him a number of Central American plant groups represented in the collections made or stimulated by Captain John Donnell-Smith; and his study (1889) of an extensive Texan collection led him even to prepare a preliminary "flora" of Western Texas (1891-1892), in a way probably giving form to his wish to see the floras of East and West brought workably together.

Monographic or "floristic" work necessarily implies the accumulation of a considerable amount of herbarium material without which, indeed, it lacks permanent verifiable value. During that part of his life in which such work engrossed much of his attention, Coulter did not escape the impulse and need of forming an herbarium, the major part of which, following the several removals of a lifetime, is housed now in the Field Museum in Chicago.

While browsing in the floristic field into which he had strayed rather than been guided, Coulter seems to have experienced the enthusiastic pleasure of every young amateur, in the true sense of the word. New "finds," interesting plants, and lists contributory to a final accounting for the higher plants of

Indiana and the western mountains, comprise the usual topics of his publications; here and there a reaction of the teacher on laboratory methods, crystals or some physiological subject, a few observations on teratological deformations, and one note on dichogamy—the only evident effect of that vitalizing interest in field observation that Darwin's beautiful studies were making known in the seventies and eighties of his century.

Perhaps the most venturesome act of a life prolonged well beyond the three-score-years-and-ten, was Coulter's establishment of a journal for the publication of this sort of casually interesting observations, to which for a time he was the chief contributor but into the columns of which others gradually entered and which long before his death had assumed a dignity and acquired an importance which must have been a source of growing delight to him as the years wore on.

The decade preceding the monographic stage of his activity did not pass by without an occasional glimpse into the significance of things which in themselves were scarcely more than interesting; for example, the distinction between the great groups of Monocotyledons and Dicotyledons (1879), the development of a flower (1883), the question of floral "adhesions" as the older morphologists had regarded them (1885), pollen "spores" (a new expression in those days), and the development of the fruit of Umbelliferae (1887). The trend of his activities in this period are nowhere more clearly indicated than in the publication in 1886 of a "Handbook of Plant Dissection" of which he was a joint author, and in which, as in much of his later work, the influence is evident of Strasburger, Sachs' great successor as a leader.

It was at this stage of his evolution that, in preparing a vice-presidential address for the American Association for the Advancement of Science, he outlined his views on the future of that field of botany which to the end he regarded as his own, "systematic" botany. As he saw it then, and evidently continued to see it, three indispensable coordinated units enter into this field, "equally important and equally honorable"; collection and description of the kinds of plants which make up the vegetation of the earth; a study of their life histories (the branch of morphology into which he was entering); and the construction of a truly natural system of classifying them.

The ten years following Coulter's resumption of active botanical teaching, at the University of Chicago, in the prime of an experienced and reflective middle age, for he was then 45, were those of his most important professional career.

In this period, realizing the fundamental taxonomic importance of ontogenetic morphology, his original publications are concerned with such topics as chalazogamy, fertilization, heterospory, gametophytes, and embryogeny. This, and the next decade and a half is the period in which appeared the "Morphology" textbooks of Coulter and his talented pupil and associate, Chamberlain, a series covering comprehensively and with various revisions both great groups of the Spermatophytes—in no small way a summation of the individual researches of the many men whose pride and joy it is to have the dissertations in their candidacy for the doctorate marked with his signature.

Coulter's place as an American teacher of botany falls in that time when he aligned himself with two men, somewhat his seniors, Beal and Bessey, in popularizing in this country the "new botany" (as one of them called it) that the masterly text book of Sachs had presented so alluringly. Of the three, he stands out preeminently as a productive investigator; with them he shares the distinction of having trained excellent workers as well as teachers; and no colleague in the United States has approved as teacher the credentials of so many recipients of the philosophy doctorate, which stamps—if it means anything—the trained workman in productive scholarship.

An admirable lecturer, from time to time he crystallized in printed form the clean-cut impressions that constituted the charm of his oral presentation before a class, and his readable texts reflect concisely and clearly the knowledge of their day in the fields that they cover.

For Coulter, environment and attendant opportunity changed, especially in the latter respect and for the better with the years. For five years, beginning with 1874, he was Professor of Natural

Sciences in Hanover College; for a dozen years following, he was Professor of Biology in Wabash College. Neither of these excellent but small colleges was largely equipped with library or laboratory facilities for more than rudimentary work, nor did either pay salaries permitting private expenditure for professional purposes beyond very narrow limits; but both were ideally located in an attractive country and in very humanly livable small communities. It was here that Coulter developed as a systematist; and it was during this period that he appears to have made the largest number of directly personal observations on nature.

As too often happens with versatile and presentable men, this period of rather broadly conceived professorships was followed by five years of administrative work; as President and at the same time Professor of Botany at the University of Indiana for two years, and as President of Lake Forest University for three years. It is greatly to his credit that he found time from executive duties during these years to do much of his best monographic work.

Like the great geologist, Chamberlin, Coulter very gladly relinquished the dignity and burdens of a presidency to head a department in the newly organized University of Chicago, and he continued in this capacity from 1896 until 1925, when, almost at the age of 74, he retired from active teaching though not from professional activity, for his remaining years were spent as Dean and chief scientific advisor of the Boyce Thompson Institute for Plant Research at Yonkers, an establishment in the inception of which he had exerted large influence and as the active head of which he had placed one of his most capable graduates. It is at once a characteristic and a tribute to the success and judgment of Coulter, that for the school of botany which he created in Chicago, as for this latest fruit of his talent, he did not find it necessary to turn to others than his own former students when filling botanical positions.

As editor of the *Botanical Gazette* for half a century, Coulter was called on to appreciate and to chronicle the passing of many botanists of eminence. These biographic and bibliographic notices were usually sympathetic and always to the point and well phrased. Quite apart from textbooks and the papers and books embodying the results of his own studies and those of his students and colleagues, for he liberally used the discoveries made by sharp eyes in what would otherwise have been perfunctory and scientifically fruitless advanced classwork—Coulter spoke often and wrote voluminously, on a large range of educational and humanitarian subjects. Among these, in his later years, organic evolution stood well to the fore; and the solid support afforded by all knowledge of nature to rational religion was never far from his mind and precept.

No account of John Coulter's personality and activities would be at all balanced if it stopped short with the recital of his influence and personal achievements in the science to which his life was nominally devoted. Though he seems not to have taken hold, in a conspicuous way, of civic movements for material betterment of the communities in which he lived, he was an active worker, and often a leader, from start to finish in movements for their human uplift.

Though never a seeker after such connections, Coulter was counted as an honored and helpful member of various organizations connected with his scientific activities, as, for example, the American Association of University Professors, the Indiana, Illinois and Chicago Academies of Science, the Botanical Society of America, and the American Association for the Advancement of Science, over each of which he presided in due course. He was elected to the National Academy of Sciences in 1909.

In no botanical association did he enjoy greater affection than in his religious fellowships. Seeing nature and its mysteries and wonders through the eyes and with the understanding of a naturalist, he saw the Author of nature through the eyes and with the faith of a Christian. For many years he led a young men's class in his church every Sunday morning when it was physically possible for him to meet with his class—and as he handled his affairs few obstacles arose that kept him from this which he regarded as the greatest of the week's privileges and duties; and his religious influence on the campus was very great.

The name of John Merle Coulter is commemorated in two genera of flowering plants, *Coulterella,* Vasey and Rose, and *Coulterophytum,* Robinson; and it cannot be forgotten at the University of Chicago so long as the Coulter Research Fellowship in his chosen field endures, for one of the last joys of his life was that of knowing that funds had been raised and accepted for the permanent endowment of such a fellowship.

Coulter is likely to be remembered long as a botanist, longer as a teacher of botany, and longest as a kindly, friendly, good and honest man of the highest ideals and possessed of the talent for inoculating others with them; but he is and will be held in most loving memory by those who knew him in his family life and to whom he was the spirit and personification of home.

The accompanying list of Coulter's publications is from the pen of his long-time associate and friend, Professor J. C. Arthur, of Purdue University.

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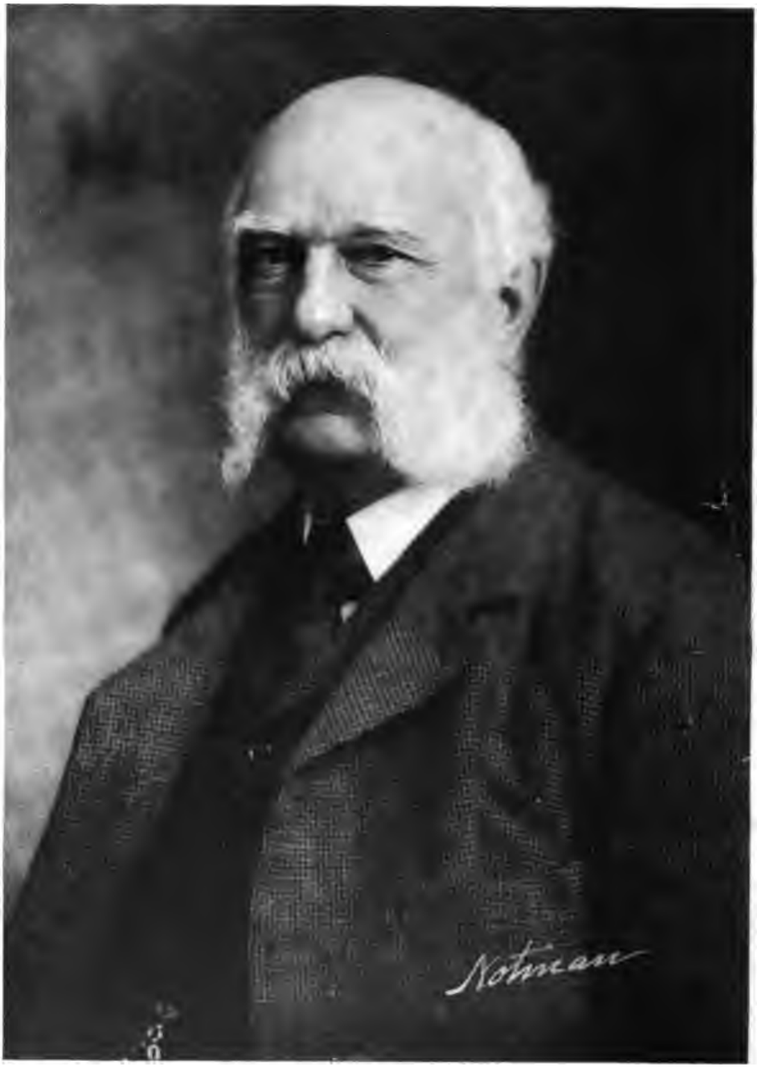

J. M. Crafts

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# BIOGRAPHICAL MEMOIR

OF

# JAMES MASON CRAFTS

## 1839-1917

BY

CHARLES R. CROSS

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# JAMES MASON CRAFTS

## 1839-1917

BY CHARLES R. CROSS

James Mason Crafts was born at Boston, March 8, 1839. His father, Royal Altemont Crafts, was a well-known merchant and manufacturer of woolens of that city. His mother, Marian Mason Crafts, was a daughter of the noted lawyer and statesman, Jeremiah Mason, of Portsmouth, New Hampshire, and later of Boston. He married Miss Clémence Haggerty, of New York, June 13, 1868, who died in 1912, several years before her husband. His death, after some years of impaired health, occurred at his summer home at Ridgefield, Connecticut, on June 20, 1917. He is survived by four daughters, Mrs. Russell S. Codman of Boston, Mrs. Gordon K. Bell of New York, and Misses Elizabeth S. and Clémence Crafts, of Boston. The two last-named have more recently devoted themselves most earnestly to the cause of the French War Charities.

As a boy, young Crafts had an unusual fondness for scientific subjects and carried on much systematic experimentation in a laboratory of his own. His liking for science was fostered by the prominence given to it in the Lowell Institute lectures and by the interest shown in his own studies by his elders of scientific training, especially by Professor William B. Rogers, later to become the founder of the Massachusetts Institute of Technology. He entered the Lawrence Scientific School and pursued there the course in chemistry, graduating with the degree of S. B. in 1858, but continued his studies under Professor Horsford during a portion of the following year. He spent the next few years in study abroad at Freiburg, Heidelberg, and Paris. The University of Heidelberg was then at the height of its scientific reputation, since Helmholtz, Kirchhoff, and Bunsen filled the three leading scientific professorships. Mr. Crafts came into intimate relations with

Bunsen and had the good fortune to work under him, acting as his assistant while the new art of spectrum analysis was in process of application to the discovery of what were then called the "new metals." At Paris he studied under Wurtz and published a number of scientific papers, both under his own name and also jointly with Charles Friedel. Friedel and Crafts became close personal friends and co-workers in many scientific researches in later years.

In 1866-7, having returned to this country, Mr. Crafts spent a short time in professional work in the inspection of mines. Upon the opening of Cornell University he became, in 1868, Professor of Chemistry, in charge of the department, remaining there until 1871.

In 1869 the resignation of Mr. Charles W. Eliot, Professor of Analytical Chemistry and Metallurgy in the Massachusetts Institute of Technology, upon his election to the presidency of Harvard University, followed by that of Mr. Francis H. Storer, Professor of General and Industrial Chemistry, who had in 1870 accepted the position of Professor of Agricultural Chemistry in the newly organized Bussey Institute, practically vacated the department of its professors.

The corporation desired that the new incumbents of the positions should be especially interested in the teaching and development of Industrial Chemistry and Analytical and Organic Chemistry respectively. To fill the first of these vacancies Professor John M. Ordway was chosen and Professor Crafts for the second. His ability and reputation were such that his accession to the staff of the institute was warmly welcomed both by teachers and students.

There was no graduate instruction given in the institute at that time and there were few students who made a specialty of chemistry. Those who did, however, found themselves fortunate in receiving a training which aimed to make scientific men as well as skillful analysts. Professor Crafts encouraged them to undertake "the investigation of unsolved problems," and a number of very creditable published papers resulted. His scientific standing at this time was recognized in his election to membership in the National Academy of Sciences in 1872.

He continued his teaching and the development of the laboratory until 1874, when impaired health made it advisable for him to relinquish this taxing work. Personal reasons and the scientific resources open to him in Paris, whose value he had already learned by experience, led him to take up a temporary residence there. It was expected that this would be only for a year or two and he remained a member of the institute faculty until 1880, when it had become apparent that his stay abroad would be indefinitely prolonged. He therefore resigned his position, much to the regret of his colleagues.

While on active duty Professor Crafts was an earnest worker in the faculty, especially in the furtherance of a rigid and broad scientific training. With several others he was particularly interested in the establishment of advanced courses of study and research in chemistry, physics, and other branches which should lead to a higher degree. That of Doctor of Science was then established, although it has never been given. The time was not ripe for such work. Indeed, it was not until 1907 that the institute conferred any degree of Doctor, which was Ph.D.

Professor Crafts remained in France until 1891, during which time he was almost constantly engaged in research, chiefly at the École des Mines, and very largely in conjunction with Friedel. These labors bore important fruit, as is manifested in the long list of valuable papers published by them, chiefly in the *Comptes Rendus* and the Bulletin of the Chemical Society of Paris. Among these researches that relating to the use of aluminium chloride as a method of synthesis, the "Friedel and Crafts Reaction," has proved to be of exceedingly great value. The Friedel Memorial Lecture given before the Chemical Society of London in 1900 by Professor Crafts contains a very complete résumé of Friedel's work, with a charmingly written brief sketch of his life history, which considers incidentally conditions relating to scientific preferment in France and moreover throws an interesting light on some phases of the religious views prevalent in that country at that time and especially of those which existed in certain provinces a generation earlier. It is an astonishing revelation of intolerance to learn that the wife of Friedel, when a child, lived "near Nismes in a house where the coffins of her relations occupied one of the drawing rooms because as Protestants they were refused Christian burial." The sanitary results of such a custom may be imagined.

The studies referred to were recognized by the award to Professor Crafts in 1880 of a Jecker Prize of 2,000 francs by the Paris Academy of Sciences, "for his researches relative to organic chemistry." In 1885 he was further made a Chevalier of the Legion of Honor.

During these years he also began an important series of researches relating to high-temperature thermometry, to which fuller reference will be made later.

Upon his return to this country he was made a member of the corporation of the Massachusetts Institute of Technology and was also invited by President Walker again to join the instructing staff. He became Professor of Organic Chemistry in 1892. Regarding the appointment President Walker said: "The accession of a chemist of Professor Crafts' reputation, a teacher of his experience and exceptional powers of inspiring interest and enthusiasm on the part of the students, marks an era in the history of the Institute." He continued to occupy this position for five years, carrying on his researches meanwhile, when he was called on to take up new and heavy duties.

The sudden death of General Walker, in January, 1897, made a vacancy in the office of president of the institute, which it was evident would be extremely difficult to fill. The number of available men proved to be very small, and after much search the committee charged with the business of selection found itself unable to come to a decision. Professor Crafts, who had been the spontaneous choice of the faculty as its chairman, had already been urged to accept the presidency, but had absolutely refused even to consider this, being entirely unwilling to break off his scientific researches and engage in executive work. A few months later, however, conditions had arisen which led him to see that it was very necessary for the best good of the institute that he should reconsider his determination. He was therefore made president in 1898, which office he held for two years.

Soon after his accession to the presidency he received the degree of LL. D. from Harvard University.

As an executive officer, President Crafts showed the same characteristics which had been evident in his earlier career. His long experience as a scientific man and acquaintance with scientific education in this country and abroad, together with his wide knowledge of the industries, gave him a very clear and true perception of the needs of a school of technology which should train men capable of meeting the professional calls of the future as they should arise, whatever these might be. In his annual reports to the corporation there is much regarding the general considerations which apply to technological education that is valuable at the present day. The occasional addresses delivered by him were of great interest and gave evidence of a remarkable breadth of literary and historical knowledge entirely apart from science. It is to be regretted that they were not published. While he was greatly hampered by lack of means, nevertheless important extensions were made in the facilities for instruction and research in many directions. A timely bequest enabled the institute to erect the Henry L. Pierce Building under his direction, which was not only excellently adapted for the purposes for which it was planned, but also, while of simple architectural design, was very satisfactory in its external appearance.

In his relations with his faculty he was invariably fair, just, consistent, and considerate of all interests. Measures which he presented to them he urged wholly on their merit and never through the authority of his position.

During the administration of President Crafts, two educational questions arose which are especially worthy of mention here.

At the wish of the Secretary of the Navy, there was laid out a three-year course in Naval Construction, particularly of war-ships, to be pursued by selected graduates of the United States Naval Academy. Various hindrances delayed further action in this direction for the time being, but the outcome was the establishment, a few years later, of such a course along the lines originally laid down, which has continued up to the present time.

President Crafts, like many others at that time and since, was strongly impressed with the belief that it would be greatly to the advantage of scientific and technical instruction in this country if in some way an arrangement of affiliation could be brought about between the Lawrence Scientific School of Harvard University and the Institute of Technology, so that the two institutions should work in harmony and join their forces for a common end as far as might be practicable, while retaining the independence of each.

Informal consideration of the matter led to the appointment of a committee composed of members of the corporations of the two institutions. The various possibilities of co-working were considered and a detailed plan was drawn up which was acceptable to the members of the joint committee. President Crafts felt very earnestly that the course of action proposed would be for the best good of both institutions at that time and in the future. But as this came to be considered more widely by those with whom the final decision rested, difficulties arose which ultimately led to its abandonment, though with the expressed hope "that as friends and earnest promoters of instruction we can so direct the course of our respective institutions that they shall mutually help one another and avoid duplication of work."

This termination of the endeavors of the committee was a great disappointment to Professor Crafts, not because a plan which he favored had failed, but rather because in his judgment a promising opportunity for the advancement of scientific education had been lost.

The labors of the presidential office, although he carried them with complete success, were not really attractive to him, especially as he found that they necessarily precluded a continuance of his scientific work, and, unwilling to set this aside permanently, he resigned the presidency in 1900.

It was felt by all his colleagues that to lose him entirely would be most unfortunate. A private laboratory was therefore provided for him, and this he fitted up according to his wishes as was necessary for the continuance of his researches.

As a result of his work at this time there appeared several papers on Catalysis. He devoted himself particularly, however, to another line of research.

A few years after the beginning of his long term of labor in Paris, he had entered upon a series of physical researches. Measurements of the density of iodine vapor and like investigations in which he engaged naturally led him to begin a precise and methodical study of the peculiarities of the mercury thermometer of precision and the sources of error which are liable to occur in high-temperature measurements, and likewise to the accurate determination of the boiling points of various substances—a matter of great importance in view of the desirability of securing fixed points of reference. The value of the results of these early studies has been strikingly confirmed by their agreement with more recent measurements. In recognition of this important work the American Academy of Arts and Sciences, in 1911, awarded to Professor Crafts the Rumford Medal, the terms of the award being "for his investigations in high-temperature thermometry and the exact determination of new fixed reference points in the thermometric scale."

To the continuance and extension of his researches on thermometry he now applied himself in his new laboratory. He devoted several years to designing and perfecting the elaborate apparatus needed for his purpose, and when this was finally completed to his satisfaction he entered upon the actual work of experimentation about 1904.

In the summer of 1911, while abroad, he suffered from a severe attack of neuritis, from the effects of which he never wholly recovered and which precluded further extended work in the laboratory. Though no longer able to continue this, however, he devoted himself to putting his experimental results into form for publication, and in 1913 there appeared in the *Journal de Chimie Physique,* Part 1 of an extended paper entitled "Points fixes de thermométrie entre 100° et 400°. Tensions de vapeur de la naphtaline, de l'eau et de la benzophénone."

This contains an exhaustive description of the form of apparatus used by him in these studies, embodying many new devices of his own. A constant volume nitrogen gas thermometer, a special type of open manometer, and also a new form of ebullioscope were employed. Of available substances tested for constancy of vapor pressure, only water, naphthaline, and benzophénone proved to be sufficiently stable. Water was found to be absolutely so between 70° and 170°.

It is the result of his studies upon naphthaline, however, to which this paper especially relates. His measurements, given in extended tables of pressure boiling-point values, run from temperatures 171° to 270° and pressures 231 mm. to 2,149 mm., the relationship of temperature to vapor pressure being capable of representation throughout by a formula. He found, moreover, that naphthaline, when properly prepared and used, retained a constant boiling point during continued boiling for twelve months. He concludes that this material has "a value almost equal to that of water for establishing temperatures," a result which, as he remarks, completely confirms his early conclusion, published in January, 1883.

A second part of the paper entitled "Tensions de vapeur de l'eau entre 40° et 100°" appeared in the same journal in 1915, whose object, as stated, relates to a much-needed revision of Regnault's tables concerning the vapor pressure of water. These tables are still used, even in their original form, although from various circumstances of Regnault's measurements, probably unavoidable in the state of scientific knowledge at the date at which they were made, there are in some parts errors which are by no means negligible. In others of Regnault's results, as, for example, the tables for the expansion of mercury, errors of as much as one-tenth of a degree are present. Regnault's tables as corrected by later scientists, of which those of Broch and Wiebe are considered the best, are probably exact between 80° and 100°, but at temperatures between 0° and 60° are open to question because of considerations which they have overlooked but which are fully considered in this memoir. These relate both to the degree of exactness of mercury thermometers, which have always been chiefly used, and to the accuracy of the determination of the freezing and boiling points of water employed in their calibration.

Regnault, while taking the utmost precautions known to him as necessary, worked at a date when various important facts as to the construction and use of thermometers of precision were still to be ascertained. The early researches of Professor Crafts in 1880 first showed how certain errors in these matters could be reduced to a minimum. Furthermore, an entirely erroneous assumption has been made as to the character of Regnault's mercurial thermometers, which have been assumed to be made of "cristal de Choisy-le-Roi," while in fact they were of ordinary French glass. Were these still in existence a comparison with the hydrogen thermometer would give new importance to the work of Regnault. But, to quote Professor Crafts, "Malheureusement, par un acte de vandalisme extraordinaire, tous les appareils précieux de Regnault ont été détruits méthodiquement pendent l'occupation de Sèvres par les Allemands."

It was the original intention of Professor Crafts to undertake a series of measurements of the vapor pressure of water between 45° and 140°, making use of the nitrogen-gas thermometer devised by himself and described in part 1 of his paper under consideration. But, unfortunately, the condition of his health rendered this impossible. He was able, however, by the use of an indirect but accurate method to determine values from 135° to 230°.

Two vessels of proper construction were placed side by side, one containing naphthaline and the other water. By suitable adjustment of pressure these were brought to the same boiling point within a few tenths of a degree, the pressure being measured by the manometers. The slight temperature differences existing between them could be measured accurately by a carefully calibrated and tempered mercury thermometer with a probable error of the result of about two one-hundredths of a degree. The method proved to be a very satisfactory one.

The results thus gained agree closely with those of Holborn and Henning, published subsequently to the actual completion of the measurements of Professor Crafts, in which the temperatures were measured by a resistance thermometer.

The latter part of the paper is devoted to a consideration of the applicability of various empirical formulæ which have been proposed to give the relation between vapor pressure and temperature. A brief article relating to this subject was published by Professor Crafts in *Comptes Rendus*, December 22, 1913. In the present paper he discusses at length three particular formulæ and considers their relations to many substances, with results shown in extended tables. He finds that these, each for a particular class of substances, may be of great service. The substance naphthaline, with which he had made an additional series of 250 experimental determinations with a new form of hydrogen gas thermometer at pressures from 80 mm. to 2,200 mm., shows so close an agreement with the formula proposed that experimental results which it fails to represent are probably due to errors in measurement.

It was the intention of Professor Crafts to complete the paper on vapor pressures by one containing the results of his measurements upon the substance benzophénone, which, however, he was not able to prepare for publication.

These papers form a fitting close to his labors, but at the same time show how great a gain to science might have been wrought had his physical strength been equal to his intellectual and experimental abilities.

Professor Crafts was a member of a number of learned societies besides the National Academy, among which were the American Academy of Arts and Sciences, the American Association for the Advancement of Science, the American Chemical Society, the Washington Academy of Sciences. He was a Corresponding Member of the British Association and an Honorary Member of the Royal Institution of Great Britain. His club membership included in Boston the Somerset and Country Clubs and in New York the University and Technology Clubs, of which last he was an honorary member. His religious affiliations were with the Episcopal Church, and for a number of years he was a vestryman of Trinity Church, in the city of Boston.

The personality of Professor Crafts was such as to impress itself upon the memory of every one who came in contact with him. He was not only a scientist of the first order, but also a gentleman of the highest culture. It was a great pleasure to his younger colleagues, who frequently sought his laboratory for advice, to enter into conversation with him regarding collateral subjects and so to draw upon his long experience and seemingly inexhaustible knowledge.

His studies involved the greatest nicety of construction of the apparatus used, which was largely done with his own hands. While his genius was by no means merely a capacity for taking infinite pains, this element of success was possessed by him in a surpassing degree.

His manner was quiet and gentle. His opinions were definite and positive, but he invariably showed great respect for the views of those who differed from him. The only thing which he seemed to hold in contempt was bad work in pupil or professor. He did not care in the least for display of any kind, and while valuing approbation at its proper worth, no desire for it ever influenced his actions. No man could have been more absolutely free from self-seeking. He had the affection of his colleagues and pupils and of the whole staff of mechanicians and janitors as well. A certain reticence of manner, wholly superficial in its character, served to protect him from triviality in those who had no claim on his attention. But when occasion called for it he showed the keenest sympathy for such as were in trouble of any kind. Speaking for those who knew him well, our remembrance of him is more and more strongly cherished with the lapse of time.

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